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OGICAL SURVEY.

ENGLAND AND WALES.

THE WATER SUPPLY
OF
CAMBRIDGESHIRE, HUNTINGDONSHIRE,
AND
RUTLAND
FROM UNDERGROUND SOURCES.

BY

WILLIAM WHITAKER, B.A., F.R.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

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MEMOIRS OF THE GEOLOGICAL SURVEY.

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Bedfordshire and Northamptonshire, 1909. Pp. vi, 230, 2 maps. Price 4*s.* 6*d.*

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Yorkshire, East Riding, 1906. Pp. viii, 181, map and 3 sections. Price 3*s.*

Also

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Notes on Sources of Temporary Water Supply in the South of England and Neighbouring Parts of the Continent, 1914. Price 2*d.*

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PREFACE BY THE DIRECTOR.

The three counties of which the underground water-supplies are described in this memoir form a convenient unit both from a geographical and from a geological standpoint; two of them are closely connected and all are of an agricultural and residential rather than an industrial or manufacturing character. In few cases are very large water-supplies required, but the number of deep wells and borings for local supplies is considerable. The geological formations from which water is drawn range from Superficial Gravels to the Northampton Sands of the Lower Oolite. Of these the Chalk takes first place as a source of water; the Lower Greensand also is of importance. The Oolites and Lias furnish only small supplies. Mr. Whitaker gives in the memoir a general survey of the geology of the three counties in relation to the water-bearing capacity of their rocks; and the details of the various bores and wells which he has collected will serve not only to show from what sources water is being at present obtained but also to indicate the most probable means of enlarging and improving existing supplies. He desires to acknowledge assistance from numerous engineers, well-sinkers and borers, who have placed their information at his disposal, as is indicated in many places in the text. Special thanks are due to Mr. W. W. Gray, Engineer of the Cambridge waterworks, for information and assistance, and to Dr. J. C. Thresh, for detailed analyses.

John S. Flett,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.
31st March, 1921.

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THE WATER SUPPLY

OF

CAMBRIDGESHIRE, HUNTINGDONSHIRE AND RUTLAND.

INTRODUCTORY.

Population.

In the three counties there is but one large town, Cambridge, and at the time of the census of 1911 that had not reached the population qualifying for a county-borough. A year after that census was taken however its population became over 50,000 though not by regular growth but through extension of boundary, the inclusion of the Chesterton Urban District.

There is now, therefore, only one other town or urban district with a population of over 10,000, Wisbech; whilst five others have reached to over 5,000, two of these being in Huntingdonshire, as may be seen from the following table. Rutland, by far the smallest county in England, does not add to the number.

The figures for dates after 1911 have been kindly given by the General Register Office. The War, of course, has prevented any full estimate being made and the figures for the civil population, in the last column, show the decrease due to the abstraction of the military and naval men.

The total population of Cambridgeshire, it will be seen, was 198,084, and that of the three counties 274,014, at the last census.

	Census of 1911.	Increase over 1901.	Estimated, 1914.	Estimated in 1916 (Civil only.)
Cambridgeshire.				
Administrative County of Cambridgeshire	128,325	8,061	130,347	118,371
Isle of Ely	69,759	5,264	71,073	66,053
Cambridge*	40,028	1,649	57,159	52,236
Chesterton Urban District	11,534	1,943	Abolished, 1 April 1912.	
Wisbech	10,828	997	11,071	10,233
March	8,403	838	8,614	8,162
Ely, City	7,917	204	7,968	7,134
Chatteris	5,259	548	5,397	4,885

* Cambridge was extended on 1 April 1912, by the inclusion of Chesterton Urban District.

	Census of 1911.	Increase over 1901.	Estimated, 1914.	Estimated in 1916 (Civil only).
Huntingdonshire	55,583	1,458	55,941	51,095
Ramsey	5,328	505	5,455	5,025
Old Fletton	5,005	420	5,111	4,897

The capital, Huntingdon, had a population of only 4,003 at the census of 1911, a decrease of 258 from 1901, and it has decreased since. St. Neots was a little ahead in 1911 and has maintained its lead.

Rutland	20,347	638	20,505	17,633 (in 1918)

Surface Levels.

Cambridgeshire includes much of the Fenland; a large part is, therefore, near the sea-level. Its highest ground is on the south and south-east, where alone is there ground above the 400-foot contour.

The highest ground is at Great Chishall (479 feet) and Heydon (439), two contiguous parishes that were in Essex when the Ordnance Map was made (Sheet 205, published in 1890), but were transferred to Cambridgeshire soon after. The other parts where the 400-foot contour is shown are over a small area W. and N.W. of Weston Green (Weston Colville), over another small area E.N.E. of West Wickham, and a still smaller one just to the South, and in a larger tract in the southern parish of Castle Camps, in which an elevation of 415 feet has been recorded.

The county therefore shows a difference of level of about 480 feet.

Huntingdonshire also extends into the Fenland; but its contours do not reach 300 feet, the highest point being 257 feet N.N.E. of Covington. There is therefore only about 260 feet difference of level in the county.

Rutland, though a much smaller county, has a greater difference of level than the others, probably about 560 feet, the lowest level marked on the one-inch Ordnance Maps being 70 feet, at Essendine on the N.E. and the highest 628, on the W., in the parish of Barleythorpe, at a spot about 1½ miles W. of Oakham.

Rivers.

The counties of Cambridgeshire and Huntingdonshire are practically in the basins of two rivers, the Ouse and the Nene, both of which, after passing through the Fenland, reach the sea in the Wash.

The only exception is a small tract at the eastern edge of Cambridgeshire, which drains to the Stour, an easterly flowing river, the head-waters of which are by Carlton and Borough Green, whilst another branch of it starts near Horseheath. Both take the drainage of a tract of Boulder Clay.

Rutland, which county was taken into this Memoir some time after it had been started, is apart from those two counties, being mainly in the upper part of the basin of the Welland which, like the Ouse and the Nene, flows through Fenland into the Wash. Its north-western part, however, contributes to the basin of the Trent, by the head-waters of the Eye or Wreak from the neighbourhood of Langham and a westerly flowing tributary of the Soar, itself a tributary of the Trent. A much smaller part of the northern border of the county, at and near Thistleton, contains the head-waters of the Witham, another river that flows into the Wash.

Small though it is Rutland can boast of having two rivers of the same name, the River Eye and the Eye Brook.

The Ouse: Main Stream.

This river forms the boundary of Huntingdonshire for some three miles, south and north of St. Neots, and then runs through that county, at first N.N.E. to Huntingdon, and then, apparently turned by the tributary Alconbury Brook, eastward to beyond St. Ives, just below which place it becomes the boundary with Cambridgeshire north-eastward to Earith.

Then it runs through the Fens of Cambridgeshire eastward to Stretham, where, after receiving the Cam, it adopts the northerly course of that river and flows by Ely to Brandon Creek, where it is joined by the Little Ouse and passes into Norfolk.

The Ouse has many tributaries in the two counties, the chief ones being in Cambridgeshire, and some of these again have tributaries of their own. These tributaries will be noticed from above downward, firstly on the right side and then on the left; and this course will be followed in other cases.

The Ouse: Tributaries on the Right Bank.

The first of these consists of the head-waters of a nameless stream which flows from near the Hatleys westward by Gamlingay to the *Ivel*, a tributary of the Ouse, in Bedfordshire. The upper part is the drainage of a clay-country (chiefly Boulder Clay); but the lower part has some water from the Lower Greensand. Another nameless stream, from Tetworth, joins the Ouse north of Tempsford. It is the drainage of a tract of Oxford Clay (? and Ampthill Clay), probably with water from the Lower Greensand at the higher parts.

The *Hen Brook* or *Abbotsley Brook* starts near Waresley and the Gransdens. Its head-waters are from the Lower Greensand; but the rest of its course is over Ampthill Clay and Oxford Clay, west-north-westward to the gravel of St. Neots, at which town it joins the Ouse.

The *Gallow Brook* is the drainage of a tract almost wholly of Boulder Clay, from Eltisley westward to the Ouse a mile or so below St. Neots.

Then there is nothing but short streamlets for several miles, until we come to another nameless stream, chiefly the result of the drainage of a tract of Boulder Clay and Oxford Clay, from Graveley, Yelling, and the Papworths flowing north-north-westward to the gravel of Fen Stanton, north of which village it joins the Ouse.

Below this are more short streams, mainly clay-drainage, and of no moment; but a longer one, nevertheless nameless, starting from various sources near Madingley, Coton, Girton, and Impington, flows northward and then north-eastward, along Cottenham Lode, part, apparently however, continuing the northerly course to the Ouse south of Aldreth. Some of the head-water seems to come from the base of the Chalk, and is supplemented by the drainage of the Gault. Near by, another stream runs along Beach Ditch to the Ouse south of Elford Closes.

The *Cam*, with its many tributaries, is the chief river of Cambridgeshire, as its name implies, and the courses of its various component streams are almost wholly in that county.

Unfortunately its nomenclature, on the Ordnance maps, is somewhat distracting, the main stream being in one part named "Cam or Granta," whilst the Rhee is dubbed "Cam or Rhee." These double names will not be used in the following description.

The main stream, to which the name should be restricted, rising in Essex, enters Cambridgeshire in the parish of Ickleton, and forms the county-boundary for over a mile northward, down to that village. It continues in its general north-north-westerly course to near Trumpington, when the inflow of the Rhee turns this into a north-north-easterly one, which it continues to hold, with only slight curvings, from Cambridge to its junction with the Ouse, east of Stretham.

Of the tributaries of the Cam on its right, or eastern side, the first is the *Granta*, a Chalk-stream with some Boulder Clay drainage, having a general north-north-westerly flow from near Castle Camps. It forms the county-boundary for some two miles, from Bartlow to Linton, and joins the Cam at Little Shelford.

Hobson's Brook, notable for having once given a water-supply to a fountain in the market-place and to the baths at Emanuel and Christ's Colleges, Cambridge, is a short stream

running northward from Great Shelford to the Cam at Cambridge.

Little Wilbraham River, or *Quy Water* starts from Chalk-springs near Fulbourn and Wilbraham, curving irregularly northward to the Cam, along Bottisham Lode.

From Bottisham, the Swaffhams and Burwell short streams find their way from the Chalk into the Fen, reaching the Cam by Swaffham Bulbeck Lode, Reach Lode and Burwell Lode.

New River, starting from the Chalk south of Exning flows northward to Landwade, and then turns westward to the Barnwell Lode, the joint-stream joining the Cam almost directly, at Upware.

Turning now to the left side of the Cam we have first a short Chalk-stream, of two branches, starting near Chrishall, in Essex and flowing north-eastward to Ickleton, where they join, just before reaching the river.

The *Rhee*, starting in the Chalk of Hertfordshire, soon reaches Cambridgeshire, west of Guilden Morden, and forms the county-boundary for about a mile northward. Then it takes an east-north-easterly course through the county, to the Cam, N.E. of Haslingfield. It receives small tributaries on its right, or southern side, the only one named on the Ordnance Map (204) being the Mill River, from the Chalk near Litlington. The village-names of Bassingbourn, Melbourn and Foulmire are derived from others, also from the Chalk. It receives also some very small streams on its left or northern side, the first, from near East Hatley, being partly in Bedfordshire.

The *Bourn Brook* is almost wholly a Cambridgeshire stream. It starts in the neighbourhood of Caxton, as the drainage of a tract of Boulder Clay, forming various streams, the resultant flowing south-eastward to beyond Bourn, when it turns eastward and receives short streamlets, the drainage of the Gault, from Kingston downward, reinforced by water from the base of the Chalk. It joins the Cam just south of Grantchester, little more than half a mile below where the Rhee comes in.

At Cambridge the Cam receives a small stream from westward and southward of Coton, with water from the base of the Chalk at the higher parts, and then drainage from the Gault.

The *Snail*, the next tributary of the Ouse, starts in the Chalk just south of Newmarket, and, after passing through that town continues its northerly flow roughly parallel to and near by New River (*see* above) to Snailwell, and then turns W.N.W. beyond Fordham and continues in that general direction, by Soham, to the Ouse opposite Little Thetford, little more than a mile below where the Cam joins.

The *Lark*, which is a Fenland Stream in our district, rises far away in Suffolk. It forms the boundary of Cambridgeshire for some 6 miles, from where it is joined by the Kennett, N.N.E. of Isleham north-westward to Lark Grange, and then

continues in the county to where it joins the Ouse south of Littleport. It has one notable tributary, the *Kennett*, which also starts a good way off, in Suffolk. It becomes the boundary of Cambridgeshire at Kentford and thence north westward to Freckenham, and again at its lower end eastward of Isleham, where it is endowed on the Map (188) with the additional name of *Lee Brook*. A short tributary, on the left, from the Chalk south of Chippenham, joins the Kennett at Freckenham, and imposes its northerly course on that river thence to the Lark.

The *Little Ouse* forms the boundary of Cambridgeshire for the lowest 3½ miles of its course, in the Fens, from the S.E. to Brandon Creek.

The Ouse: Tributaries on the Left Bank.

The *Dulge Brook*, in the middle part of its course through a tract of Boulder Clay, forms the southern boundary of Huntingdonshire for about 1½ miles, from a little west of Bushmead Priory to east of that place. The rest of it is in Bedfordshire.

The *Kym*, formed from the drainage of Boulder Clay and Oxford Clay, enters Huntingdonshire west of Tilbrook, its head-water, in Bedfordshire, being given the name of the *Til* (map 186). It flows in a general E.S.E. direction to the Ouse, a little northward of St. Neots.

Diddington Brook, also from the drainage of Boulder Clay and Oxford Clay, flows from near Long Stow eastward to the Ouse by Offord Cluney.

Alconbury Brook which, with its tributaries, results from the drainage of a large tract of Boulder Clay and Oxford Clay, has two branches, to the northern of which the name is given on the maps (172, 187), which join some two miles west of Huntingdon, the combined stream then flowing eastward to the Ouse at that town.

The southern and nameless branch is an easterly flowing stream. It enters Huntingdonshire in two channels in the parish of Keyston southward of the village, and has a course of several miles to its junction with the other branch.

This latter starts in Northamptonshire, but very soon becomes the boundary of Huntingdonshire, for half a mile, below Luddington-in-the-Brook, then passing into that county, with a general south-easterly course, by Hamerton, Alconbury Weston, and Alconbury, to the junction with the other branch.

It has a fairly long affluent on the right, from N.W. of Old Weston, flowing at first south-eastward and then eastward, to the Brook, about a mile above its junction with the other branch, with which it has for the most part a roughly parallel course.

On the left the Alconbury Brook has a tributary starting in Northamptonshire, but very soon entering Huntingdonshire,

and flowing S.S.E., eastward of the Giddings, to the Brook a mile below Hamerton.

Below Huntingdon there is no stream of note on the left side of the Ouse, but the drainage of a small tract of Boulder Clay and Ampthill Clay finds its way to the river just below St. Ives.

The Nene: Main Stream.

This river becomes the boundary of Huntingdonshire in the Lower Jurassic tract just south-west of Elton, and continues as such (either the river or a loop of it) north to Wansford. Then it turns and meanders (still as the county-boundary) in a general easterly direction to Peterborough, where it enters the Cambridgeshire Fens and has an artificial course E.N.E. to Wisbech, where it turns northward, and then directly passes into the Norfolk Fens.

The Nene: Tributaries on the Right Bank.

The *Billing Brook*, starting in Northamptonshire, soon passes into Huntingdonshire, west of Morborne, and flows northward to the Nene, west of Water Newton. It is at first merely the drainage of Boulder Clay; but its lower part is in Jurassic beds, and receives water from the limestones thereof.

A nameless stream, which, with its small affluents results from the drainage of a tract of Boulder Clay, starts at Morborne and takes a general north-easterly direction to the corner of the Fens at Stanground.

Another stream, which rejoices in two names, Pig Water and River Nene (old course), on sheet 172 of the Ordnance Map, starts at Yaxley and flows north-eastward along or near the edge of the Fen, to Horsey Hill, where it enters the Fens and takes a general easterly direction along King's Dike and Whittlesey Dike, and again as River Nene (old course) through March to Wisbech Canal at Outwell, and flows along, under this name, north-westward to the present Nene at Wisbech.

Southward of Yaxley are small streams, the drainage of a clay-tract, which may be taken as in the Nene system. All flow into the Fens. One of them results from the drainage of the Boulder Clay around Caldecote and Denton, flows eastward to the Fens south of Holme, and is endowed with the name *Holme Brook* on the old map (Sheet 64). Another drains the Boulder Clay tract of Glatton and Sawtry, passing eastward by Conington.

A longer but nameless stream, with many small affluents, takes the drainage of a large clay-tract. The main stream starts west of Abbots Ripton, flows north-eastward for a short way, but soon turns to a general south-easterly direction to King's Ripton, where it turns north-east to Broughton and then

northward to Ramsey, and there joins another River Nene (old course) which then flows north-eastward to the first-noticed old-course at Floods Ferry.

The *Old Croft River*, a purely Fen-arrangement, wanders north-north-eastward from close to Littleport, by Welney to the old course of the Nene just south of Upwell.

Left Side of the Nene.

In our district the Nene receives no definite tributaries on the left side, where it is wholly in the Fens, here, as elsewhere, cut up by dykes; but the *Cats Water*, which forms the boundary of Cambridgeshire from Peterborough for several miles north-eastward, where it takes the name of *Old South Eau*, is described on the old map (Sheet 64) as "anciently a branch of the Nene River." The Nene, therefore, gives us a good illustration of the alterations and artificialisation of Fenland streams.

The Welland.

The main stream forms the boundary of Rutland on the south and south-east from Caldecott to below Tinwell, with some small exceptions, where that boundary shifts to a short distance from the river. These are in the parish of Liddington at Thorpe-by-Water, E.S.E. of Seaton, and just S.E. of Tinwell, two being to the right and two being to the left.

In this course the Welland receives but one small short stream on its right side, but on its left side, in Rutland, it receives great additions, as follows:—

The *Eye Brook*, starting from near Tilton, in Leicestershire, reaches Rutland more than a mile west of the village of Allexton, where it becomes the county-boundary for most of the distance before it joins the Welland.

The next tributary of any note is a short stream, rising just north and just south of Uppingham, the two branches joining more than 1½ miles eastward of the town. The water seems to come chiefly from the Northampton Sand.

The *Chater* rises in Leicestershire, but soon enters Rutland and flows in a general easterly direction to the Welland just above Tinwell. Whilst partly the result of clay-drainage it also gets water from permeable beds (Marlstone, Northampton Sand and Lincolnshire Limestone). A tributary stream, from the neighbourhood of Riddington and Ayston, has a nearly parallel easterly course to Morcott, when it turns toward the Chater and enters it on the right bank at South Luffenham.

The *Gwash*, starting from the drainage of a clay-country just west of Rutland, enters that county in the parish of Braunston and thence flows eastward to Ryhall, where it turns south and passing out of the county for over a mile joins the

Welland just below Stamford. On its left side this river receives a very short stream from the north of Braunston, another short stream from west of Egleton, and a longer one which starts from around Oakham and flows eastward to join the main stream S.E. of Whitwell, being partly the result of the drainage of clay-tracts and partly of water from the Marlstone and the Northampton Sand. Still lower is a tributary from combined streams starting at and southward of Cottesmere joining near Exton Park, and then going south to the Gwash just below Empingham. This stream seems to come largely from Northampton Sand and Lincolnshire Limestone. On the right bank the river has no notable accession, only mere driblets.

Methods of Water Supply.

Within the three counties water is chiefly got by means of wells, though some small supplies come from springs; and it is notable that the largest town, Cambridge, was once supplied from Chalk-springs, long since given up and supplanted by wells (*see* p. 57); whilst the second largest town, Wisbech, still gets its water from springs, which however come from the Chalk in the neighbouring county of Norfolk and are therefore described in the Memoir on that county.

Two Huntingdonshire towns, Huntingdon and St. Neots, get a supply that can hardly be classed under wells or springs, by shallow works that drain a tract of River Gravel, which seems to be their only available source.

Ramsey is without a public supply. In all these there is great doubt as to the probability of a good supply being got by piercing the thick mass of clay which hides the Jurassic limestones, the outcrop of which is far away.

In Rutland there are large outcrops of permeable beds of Jurassic and Liassic age, these beds being underlain by clays, so that wells can be readily made, and springs are also available. On the other hand there are no large spreads of gravel.

None of the wells (borings) are very deep; in four cases only have we records to the depth of 400 feet, and two of these only just reach that, at Cheveley in Cambridgeshire and at Uppingham in Rutland; the others are both in Cambridgeshire, at Sawston, 433 feet deep, and at Whittlesford, 455; but, strange to say, this deepest case is wholly in Drift, giving evidence of a very deep channel filled therewith.

Since the above was written, however, a boring of over 500 feet has been made at Bury, near Ramsey (*see* p. 102).

The only record of public surface-supply to hand is from the Local Government Board Return of 1915, p. 436, where the water from the Ouse (at Staunch), presumably taken as one of the supplies for St. Ives, is said to be liable to contamination.

GEOLOGIC FORMATIONS.

General Account.

One of the chief characteristics of Cambridgeshire is that it contains a large part of the Fenland, that great flat alluvial tract resulting from the deposit from the various rivers that flow into the Wash. Huntingdonshire also claims a small share in this, the largest spread of low-lying land (practically at about sea-level) in the kingdom.

Whilst Cambridgeshire is chiefly a Cretaceous county with a fair outcrop of Upper and Middle Oolitic beds, Huntingdonshire is purely an Oolitic one, with the Middle and Lower divisions. Rutland, which is detached from these, is formed of Lower Oolitic and Liassic beds.

In all the counties various beds of the much newer Drift Series are found, resting irregularly on all the other formations.

The following is a list of the beds that are shown on the Geological Survey maps, on the right, with their classification on the left, and their thicknesses, as far as these can be given:—

Formations.	
Recent	Alluvium up to 30 feet, sometimes divided as below:— Alluvium of Fen Meres. Shell Marl. Fen Silt. Peat.
Post Glacial Drift ... ... (of no great thickness)	Valley or River Gravel, &c., sometimes divided as below:— Gravel of Modern Rivers. Gravel of Old Rivers. Sometimes Estuarine or Marine Gravel.
Glacial Drift ... ... (up to 180 feet; but more in certain channels)	Loam (on Boulder Clay). Gravel and Sand (on Boulder Clay) or Plateau Gravel. Boulder Clay. Gravel and Sand.
Upper Cretaceous	Upper Chalk, up to 237 feet. Middle Chalk, 210 to 230 feet. Lower Chalk and Chalk Marl, 160 to 170 feet. Gault, 70 to 242 feet.
Lower Cretaceous	Lower Greensand, 12 to 120 feet.
Upper Oolite	Kimeridge Clay, 100 to 142 feet.
Middle Oolite...	Calcareous Grit } of no great Coral Rag } thickness. or, in Map 187, new series. Ampthill Clay } 26 to 150 feet. Elsworth Rock } Oxford Clay 400 to 700 feet?

None of the Cretaceous beds occur in Huntingdonshire; but that county continues the series downward, as follows:—

Lower Oolite	Cornbrash, 0 to 15 feet.	
	Great Oolite Clay, 5 to 40 feet.	
	Great Oolite Limestone, 10 to 17 feet.	
	Upper Estuarine Clay	30 to 40 ft.
	Lincolnshire Limestone (Inferior Oolite).	
	Lower Estuarine Series	
	Northampton Sands, about 17 feet.	

The following are proved only in borings in Huntingdonshire, Upper Lias, 85 to 101 feet, Middle and Lower Lias, up to 265 feet. But Rutland adds to the list of formations at the surface, the three divisions of the Lias (Upper, Middle and Lower), with the following two subdivisions:—

Middle Lias	Marlstone.
	Clays and Sands.

Of any older beds we have no record, no boring having been carried into them.

Water-Bearing Beds.

Starting at the top of the geologic series with the various gravels of the Drift, we pass down into the Cretaceous Series (Chalk and Lower Greensand) and then into the Jurassic (the various calcareous and sandy beds of the Oolites and the Lias), the permeable beds of the latter two sets being separated by clays which hold up the water in them.

The amount of water that any geologic division can absorb from the rain is dependent on its composition and structure, sands and gravels, allowing of the infiltration of water through the mass, whilst in limestones or other hard or compact rocks the more or less vertical planes of jointing and the more or less horizontal planes of bedding come into action, so that a rock not specially permeable in itself may yet yield water along its structural planes.

The amount of water that any permeable formation can yield depends on various factors: notably on the area of its outcrop which, of course, determines the amount of rain that falls on it; and on its thickness, which determines its capacity for storing water. Its position also as regards underlying and overlying impermeable beds is important, and there are other points to be taken into account in exploiting any particular formation.

It should be understood that the various beds which we are now passing over as not water-bearing, are not so strictly impermeable as to be wholly without water. A formation that is nearly always a fairly stiff clay may in places contain beds of a more sandy kind, which will give very small and very local supplies.

As an instance F. R. C. Reed has said: "The water supply from the Jurassic clays is comparatively small and is derived from the bands of limestone, nodules and septaria which occur in them. But there is some uncertainty about obtaining water from them, for in wells at Conington and Bluntisham a depth of 300 feet was reached without success, whereas at Redhill, a farm west of Conington, a good spring was met with at a depth of 12 feet."[1]

What we are now concerned with are those beds whose habit it is to yield water, and from which a supply may be expected, except under certain unfavourable conditions.

Gravels and Sands of the Drift.

These, the most permeable beds with which we are now dealing, occur at various geologic horizons and at various levels. Despite their different ages, however, we may now treat all as one, each particular set occurring apart from the others, and all having practically one sort of composition: stones of varying kinds (but mostly flint) and of many sizes, generally in a sandy matrix, and often with layers or masses of sand.

Besides their advantage of permeability these beds have also, except where of a coarse character, the property of a good filtering material; so that, under favourable circumstances, good supplies of water may be got from them. It must not be forgotten however that the very character which makes them permeable to the falling rain also lays them open to the reception of polluted matter; so that care is needed in their use for water-supply. They should be guarded from pollution and should not be used in the immediate neighbourhood of population.

In Huntingdonshire the River Gravels are of no small importance, and perhaps they will be more widely used in the future.

The Chalk.

We now come to the formation that is perhaps the most important in the country as regards water-supply: certainly, at all events in the South of England. Its only great rival is the New Red Sandstones of the Trias, the great water-bearing beds of the Midlands.

In our three counties, however, the Chalk is of effect in only one. The chief towns of Cambridgeshire, namely Cambridge, Wisbech (with part of March) and Ely, with the smaller ones of Linton and Newmarket, get their main supply from it.

As a general rule it is that wide tract of the Chalk that reaches inward from the escarpment and consists at the surface mainly of the Upper division, though in parts the Middle division is fairly represented, from which the chief supplies of

[1] "A Handbook of the Geology of Cambridgeshire," 8vo, Cambridge, 1897, p. 240.

water are got; but it is not so in Cambridgeshire, in which no large supply is got from the Upper Chalk.

In most parts the downward slope of the Chalk, outward from the top of the escarpment, is short and sharp, having therefore but little breadth; but in Cambridgeshire, as in Norfolk, we find a different state of things, the slope of the escarpment being at a less angle than usual, so that there is a broad tract of ground between the top of the escarpment and the boundary-line of the Chalk, several miles in extent indeed, instead of the half mile or so of some places. From this it results that the Middle and Lower Chalk (and mostly the latter) are the divisions from which water is got.

There is one remarkable difference in the two kinds of Chalk-tract, as regards water. Whilst in the inward tract, as it may be called, both the dip of the beds and the slope of the ground have the same general direction (away from the escarpment) in the outward tract, whilst the dip is in the same general direction as in the inward one, the slope of the ground, away from the escarpment, is in a reverse direction.

The plane of saturation in the Chalk, or the water-table as it is also called, varies in depth generally with the height of the surface, water being reached at greater depths on the higher grounds, where a considerable amount of dry Chalk has to be passed through before water-bearing rock is reached, whereas it is found at no great depth in the low ground.

Whilst then in the inward Chalk-tract the slope and the dip are more or less in the same direction, in the outward tract the contrary is the case: thus in Cambridgeshire the dip is generally in a direction more or less south-easterly, whilst the general slope is in a more or less north-westerly direction. Of course the slope is greatly varied locally, according to the very irregular erosion that has formed the surface.

It has sometimes been said that the Lower Chalk does not yield much water; but, in Cambridgeshire at all events, it is not open to this reproach. Of course, taken as a whole, over a vast tract like the London Basin (of which the Cambridgeshire Chalk is a part) the Upper division has by far the widest outcrop, and therefore gives the greater area of exposure to the rain; but in most parts the smaller area of the Middle division and the far narrower one of the Lower are by no means negligible, the latter being notable for its springs. And when there is a broad outcrop of these divisions they are very important in the matter of water-supply, as in the present case.

Objection is often taken to Chalk-water on account of its hardness, which is owing to the amount of chalk that has been dissolved during the passage of the water through the beds, and its retention. This, however, can be easily cured by the process of softening, which could often be done with advantage. That there is any great difference between hard and soft waters, in the matter of the general health of the users, is doubtful. It

has been shown by Dr. J. C. Thresh, that in the large adjoining county of Essex, where large populations use either soft, moderately hard, or hard waters, there is no connection between the hardness of the water and the death-rate.[1]

Many years ago W. H. Penning discussed the subject of water-levels in the Chalk near Cambridge in the Geological Survey Memoir on that district, and his remarks, which are of general as well as local interest, are now reproduced, with a number of small corrections. The text and the figures are notable as a somewhat early attempt to illustrate the subject of water-levels in the Chalk.

The Chalk here, as elsewhere, is pre-eminently a water-bearing formation, any wells carried down to the plane of saturation being invariably supplied. In this area, where the Chalk comes to the surface the plane of saturation is naturally low down in the formation, being at its base along the boundary. As the Chalk dips down the plane rises, not relatively only as the Chalk-base falls, but actually beneath the higher ground. Except where the Chalk passes in under impervious Eocene beds or Boulder Clay, it is necessary for all wells that depend on a supply from below the line of saturation to be dug down to it, as the water would not rise in a boring. It is only when the line of saturation is depressed by an overlying impervious stratum that this result can be obtained.

The plane of saturation almost invariably rises beneath high ground in a Chalk-area, because the rain which falls on the surface percolates downwards, and feeds the sources of supply as quickly as the water is drawn off by the springs and streams of the district. As the water-level falls, and the hydrostatic pressure lessens, the springs and streams fall off, as it rises they increase; thus a general balance is maintained, the height of the plane rising above the spring before it can counteract the friction of the water passing through the rock. The plane, therefore, has generally a definite and constant relation to the valleys of a district, abnormally affected in some instances by the dip of the beds. A good instance of this is furnished by the Gog Magog Hills, where a synclinal dip depresses the water-plane by throwing out the splendid springs which once supplied Cambridge.

We have been enabled to work this point out in a detailed manner through the kindness of H. Tomlison, then Engineer to the Cambridge Waterworks Company, who has furnished us with the particulars of many wells in the neighbourhood. From these we have constructed two nearly parallel lines of sections, Figs. 2 and 3, running along the flanks of the Gog Magog Hills, and connected them by a cross-section (Fig. 1). Wells have been dug at all the points indicated, to a few feet below the plane of saturation, and these show it to be as represented by the continuous lines, *a*, *a*, in the diagrams. It should be noted,

[1] "The Water Supply of Essex," 1916, pp. 67–69.

however, that later information has led to some of the levels being questioned, according to W. W. Gray.

It will be seen that the water-level rises generally under the higher parts of the surface, from N.W. to S.E. along the longitudinal sections; and it has a tendency to rise from Fulbourn Mill towards the Hills Farm, as well as from Stapleford Mill towards Heath Farm in the cross-section. But a local depression occurs, the greatest amount of which is beneath the highest ground of the Gog Magog Hills, where it might be expected to be relatively high and to follow the dotted lines *b*, *b*, in the sections. The plane of greatest depression coincides with the line of hills, and passes from Copley Hill, through Vandlebury, west of the Quaker's Charity Farm towards Cherry Hinton.

The Chalk here lies in a synclinal hollow or trough, the inwards dip from each side having mainly contributed to the formation of the hill by preserving its beds, while those on either side were removed by denudation. The broken lines represent the lines of division of the Lower Chalk, dipping towards the escarpment in the longitudinal sections and in the cross-sections forming synclinal troughs beneath the Gog Magog Hills.

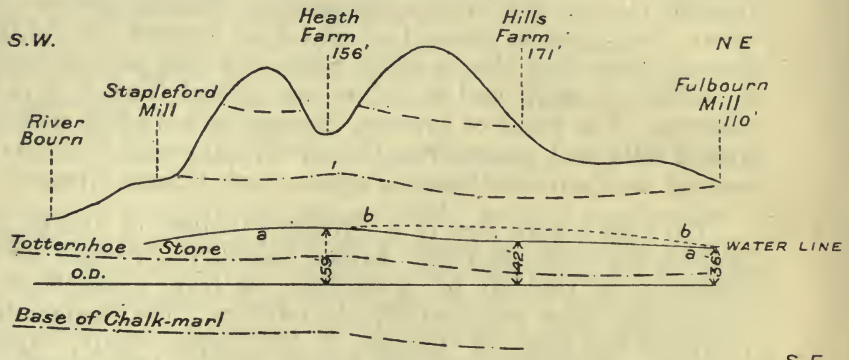
It will be seen that there is a close correspondence between the cross-section of the larger of these troughs and that of the plane of saturation, although the latter under normal conditions would differ from the former in being higher rather than lower along the central line. There is probably some connection between them, of which we believe the following to be the true explanation.

The Totternhoe Stone, at the top of the Chalk Marl, holds the water that has percolated down to it through the overlying permeable chalk, as is shown by the line of springs which frequently follow its outcrop. The stone is here, in common with the other beds, thrown into a trough, along the bottom of which water would flow somewhat more freely than elsewhere. The line of depression (which coincides with that of the hills) extends towards Cherry Hinton, where there is one of the finest springs in the county. This spring, where the trough runs out to the surface of the ground, throws out (owing to that circumstance) an undue proportion of water, thus permanently lowering the plane of saturation along the synclinal axis, where the water moves most freely.

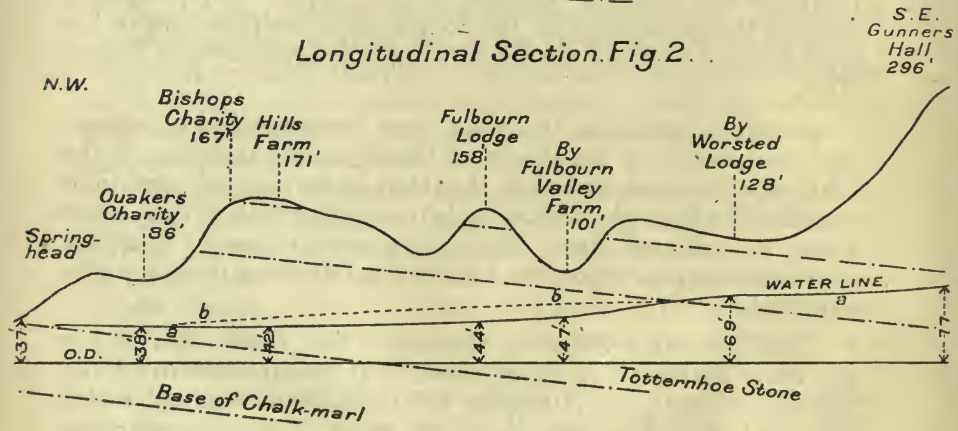
Water, even permanent springs, may be met with in fissures in the Chalk before reaching the line of saturation, but it is always uncertain; indeed the whole thickness of the Chalk may be penetrated without finding any great quantity of water. But there are generally some indications, especially in wells that are dug to any depth, which, if observed in connection with the dip, structure, and general conditions of the beds, may lead to the desired result.

Sections illustrating the Water-level in the Chalk beneath the Gog Magog Hills. Horizontal scale, 1 inch to a mile. Vertical scale, 1 inch to 200 feet:—

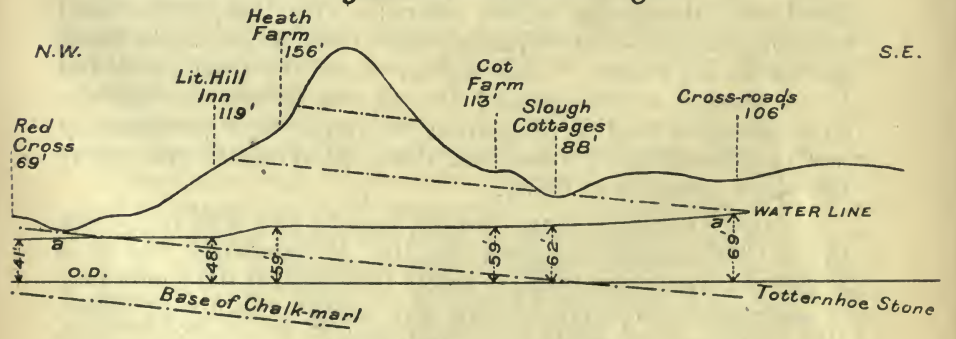
Cross Section. Fig. 1.



Longitudinal Section. Fig 2.



Longitudinal Section. Fig. 3.



We may here introduce some remarks on the flow of water in the Chalk and on the porosity of the Chalk, with reference to the neighbourhood of Cambridge.

In his report to the Local Government Board on Fulbourn Asylum Dr. COPEMAN said, in 1906, that a hole was made, east of the Asylum, "roughly about 6½ feet deep by 6½ feet by 2 feet, but somewhat narrower towards the bottom," the space estimated "at about 75 cubic feet, which would be capable of containing about 453 gallons." The top foot consisted of soil, beneath which was fairly compact Chalk Marl, which showed fissures, mostly small toward the bottom.

"In order to test the permeability . . . . . water was turned into the hole . . . . . at the rate of about 60 gallons per minute, which, supposing the hole to be impermeable, would have sufficed to fill it in a little over seven minutes . . it took no less than 85 minutes to fill up to the 6-ft. mark, during which time . . . . 5,100 gallons of water had been run in." On stopping the flow "one-half of the contained water had again disappeared in 12 minutes, although the last foot of water took an hour to soak away, owing in large part to blockage of the crevices of the chalk."

Dr. COPEMAN'S remarks on the direction of flow of the water are given on pp. 37, 38.

In November 1906, for the purpose of a Report on the best method of disposal of the sewage of the Fulbourn Asylum, Dr. J. C. THRESH had 13 borings made in part of the field south-westward of the burial ground (N.W. of the Asylum) to test the accuracy of the geologic map; they showed that the Totternhoe Stone was rightly marked.

All but two of these were shallow (to the depth of from 4 feet, in most, but to 7 feet in four), the other two were taken deeper; in the case of No. 1, which was near the S.E. corner of the field, to 30½ feet, and in that of No. 13, just north of the middle of the field, to 30 feet, for the purpose of making fluorescein-experiments.

This gave the following result:—"into 13 was placed an amount of fluorescin dissolved by aid of an alkali in about 200 gallons of water, capable of giving a distinct colour to 25 million gallons of water. After all had been absorbed, and this took place somewhat slowly, samples of water were taken from . . . . points at intervals extending over 37 days, and on no occasion was the slightest indication obtained of the presence of the colouring matter." These points included boring No. 1 (? 110 yards off) Butcher's Farm, Laundry and Baths at Asylum, Cherry Hinton Vicarage, and Caudle Ditch.

"Special watch was kept over the Asylum baths and laundry when the water could be obtained in bulk, but no signs of the colouring matter ever appeared."

In January 1907, Dr. D. FORBES and E. W. HARRY criticised Dr. Thresh's remarks in a Report to the Borough of Cambridge.

They "agree that there is a very gradual movement of water from the central high lands to the peripheral low lands, but the rate of flow is slow compared with that of local currents, and cannot be depended upon to prevent sewage finding its way East or West;" and they say of Dr. Thresh's fluorescein experiment, that it "is a single experiment with negative results."

They "are not satisfied that the proposed scheme (of sewage disposal) is one free from danger to the water supply of Cambridge and the Asylum."

I do not feel certain of the existence of local currents in the underground water of strength enough to interfere seriously with the general flow, though of course the latter here as elsewhere is subject to local changes in direction.

In a later Report, April (1907) Dr. THRESH describes an experiment made to test the porosity of the soil at this site, and the direction of flow of the water.

"The porosity was ascertained by noting the rapidity with which water percolated through it [the soil]. Water was pumped from two bore-holes made at points on the 50 ft. contour line," which bores yielded water freely.

"A trench was cut from a point 6 yards north of the south bore [No. 1] to a point 6 yards south of the north bore, [No. 13]. This was 98 yards long, 1 foot wide and 6 inches deep. Water was pumped in from the south bore at the rate of 25,000 gallons per day. The water filtered through so quickly that only about 50 yards of the trench was commanded, when the second pump [at boring 13] was started, the whole trench could be commanded, but it could not be filled. A trench was then cut at a right angle to the first (22 yards long) towards the west. . . . Pumping was kept up for six days at the rate of 50,000 gallons per day, and the water was easily absorbed by the soil. The trenches were then divided into sections of 6 feet, and a definite amount of water put in each. The time which the water required for absorption by the soil varied from 16 to 90 minutes Where the water percolated most quickly the soil was found to be more sandy."

"The direction of flow of the underground water had been left in doubt by the experiment detailed in my first report," the fluorescein not having been again seen. and a further experiment was made as follows:—

"After the ground under the trench had been thoroughly saturated with water by three days' pumping the fluorescein experiment was commenced on March 8th. A tub was mounted at each end of the long trench . . . . and in each was placed one pound of fluorescein dissolved in water by aid of an equal weight of caustic soda. Whilst pumping was continued the solution was allowed to dribble into the water as it entered the trench. The time occupied in dribbling in each pound was on an average four hours. Four pounds were put in on the 8th,

four on the 9th, and two pounds on the 10th. On the 16th a single pound was dissolved and run direct into the north bore-hole."

"The fluorescein added would colour most distinctly 110 million gallons of water, and even in 200 millions its presence could be detected under favourable conditions . . . ."

"Notwithstanding the large amount of fluorescein used . . . no trace of colour ever appeared in the south bore-hole six yards from the trench, whilst it appeared in the north bore-hole in seven hours after the commencement of the experiment. No trace has been detected at the Asylum well, or at the Fulbourn pumping station, or at the Cherry Hinton springs. Water has been examined from the old bore-hole between the trench and the Asylum, but no trace of colour has ever appeared there. At a hole dug near the Asylum graveyard no colour has been found . . . . Professor Hughes selected a site for a trial boring, between the trench and Butcher's Farm, as it appeared possible that the water might be travelling in that direction; but although a large amount of water was pumped from this bore, no trace of colour has been seen, nor has the spring water at the farm been affected."

"On March 7th, nine days after the commencement of the experiment, water in the chalk pits towards the north-west was found to be tinted, and continued so for some days . . . ."

"Since then the colour has occurred in the well at the Rosemary Branch Public-House in the same north-westerly direction; on March 31st and on April 7th it was detected in the water at Leddon wells."

"During all this period pumping has been in active operation at the Fulbourn Asylum well and at the Fulbourn well. Notwithstanding this no fluorescein has appeared at either well."

From this it is concluded "that the ground water here is travelling towards Leddon wells, and away from all the large sources of water supply."

Analyses of the waters support this view. Those of "Cherryhinton springs, the Asylum well, and Fulbourn well are practically identical. All contain under two parts of chloride per 100,000."

"The water in north bore-hole contains 3·1 parts, in the chalk pits 3·4 parts, and at the Leddon wells 3·7 parts. These figures are consistent with a flow from the north bore-hole towards Leddon wells, and opposed to any flow towards the Asylum or the Fulbourn well."

Moreover, "the Asylum well yielded a water of a little higher degree of chemical purity than the Cherryhinton springs or the Fulbourn well, notwithstanding the proximity of the first named to the existing sewage irrigation area."

As regards the direction of flow at Cherry Hinton there is unfortunately a disagreement, as noted in the Report of Dr. Thomson and P. M. Crosthwaite to the Local Government

Board, in 1908, in which they say (p. 5) that "according to Mr. Gray's observations the water-level under Cherry Hinton village falls from south to north, which would point to a flow of underground water away from the Company's spring to the north. Our observations, on the other hand, show a fall of level from the north to the south, pointing to the flow of the water under the village being towards the Company's spring."

"Examination of the well (water) levels noted by us . . . . will show that these point to a water surface sloping towards the Company's spring from the south, south-east, and north, and away from it to the west, indicating a flow of underground water in correspondence."

As to Fulbourn they say that "observations of the water-levels of wells on the south, east, and west of the pumping station show . . . . a fall of level in the water surface on all these sides towards the Company's well." They differ from Dr. THRESH'S conclusion as to the flow near the Rosemary Branch Inn (*see* above).

Lower Greensand.

Although it is of no great thickness and has no broad outcrop in Cambridgeshire, yet the Lower Greensand is of importance as regards water. At the far west of the county there may be more of it than elsewhere; but on turning our eyes from the ordinary geologic map, without Drift, to one on which Drift is shown, we see that the apparently broad outcrop there, around Caxton, is deceptive, for the sand is wholly hidden by a capping of Boulder Clay, probably in great part of considerable thickness and impermeable, which extends some way into the adjoining county of Bedfordshire. There could hardly be a better case of the danger of forming a judgment without a Drift-map.

Nevertheless, the formation consists for the most part of such permeable material (sand) that it readily absorbs water, and allows it to flow underground more or less in the direction of the dip, the water being held up by the underlying Jurassic clay.

In no county has the Lower Greensand been so thoroughly exploited for water as in Cambridgeshire. Most of the many "Coprolite Works" where the bed of phosphatic nodules at the base of the Chalk has been worked for the manufacture of artificial manure, had borings through the Gault into the sand beneath, which were successful in getting a supply of water, which sometimes rose to the surface. There are still overflowing wells, as at Meldreth, where borings have been carried through the Chalk Marl and the Gault into the sand, and the town of Cambridge gets a supplementary supply from the same source, at Cherry Hinton (*see* pp. 64, 65).

Ely, too, I believe, once got its water from a well in the Lower Greensand. The East Hunts. Co. also gets a supply from this formation. Nevertheless, it is probable that no very large supply could be got at any one place from this formation, which cannot be exploited in the same way as the Chalk, by means of horizontal work, that is by headings through the beds below the plane of saturation.

Wells made in the Lower Greensand, where it is at the surface, are open to the same objection as is made to wells in the Drift Gravels. The sand is there exposed to surface-pollution; and it is essential, therefore, that this should be guarded against. There is then an advantage in reaching the sand through some amount of Gault, as that clay acts as a protective capping.

The water from the Lower Greensand is usually soft, unless (as in some other counties) there are calcareous beds. A not uncommon fault is that it is sometimes ferruginous, from the occurrence of iron-sand or iron-sandstone, which is common in Norfolk.

Middle Oolite Limestones.

These are all of little thickness and with narrow outcrops, the only exception being the Corallian limestone of Upware, which has an outcrop nearly three miles long by up to three-quarters of a mile wide, and an estimated thickness of 54 feet. As, however, there is hardly any population on it and but little near it, and as it probably has little underground extension, it is neglected from the point of view of water, though of great note amongst geologists.

The *Calcareous Grit* (of about the same age) shown on the old maps (52, N.E. and 51, N.W.) is insignificant, and moreover is almost wholly covered by Boulder Clay. Possibly it is the same as the following:—

The *Elsworth Rock* is of purely local occurrence, confined according to the new map (187) to the neighbourhood of the Cambridgeshire village of Elsworth, to the adjoining part of Huntingdonshire, to the west and south-west, where, however, it is mostly covered by Boulder Clay, and to the neighbourhood of St. Ives, on the other (northern) side of the Ouse. Clearly it is useful only for small local supplies.

It is of interest to add that I have seen (1919), in a very large clay-pit just westward of Warboys station in Huntingdonshire, a long continuous bed of clayey limestone, 4 or 5 ft. thick: enough to be used for burning into lime, which of course is a bed that might yield some small supply of water (from Oxford Clay).

Lower Oolite Rocks.

The *Cornbrash* is a thin limestone, and of no importance as regards water. It comes to the surface over rather more than

2 square miles in the north-western corner of Huntingdonshire, from Elton to Chesterton, and occurs also in some small patches with an insignificant total area at the eastern end of Rutland. As it rests here on the Great Oolite Clay its water is separated from that of the limestone of that series.

The *Great Oolite Limestone* has a short and narrow outcrop at the north-western corner of Huntingdonshire, perhaps totalling over two square miles; but in the eastern half of Rutland it forms a larger part of the surface, chiefly in the form of outliers, in some of which its surface-area would be larger but for cappings of Boulder Clay. No supply of note has been got from it.

The *Inferior Oolite, or Lincolnshire Limestone*, has a short, narrow and very small outcrop at the far north-western end of Huntingdonshire; but in Rutland there is more of this division at the surface than of any other water-bearing bed, and the broad continuous outcrop runs right across the county from north to south.

Nevertheless, as the towns of Oakham and Uppingham are on lower beds, this source of water is used only for small supplies. There is a large amount of Boulder Clay capping, chiefly on the north; but not enough to prevent the access of a large amount of rain, the bare surface of the limestone being in excess of the clay-capped parts, even on the north.

Of the Jurassic limestones in Rutland, W. J. Harrison has said that swallow-holes "in the limestone beds are frequent. They mark the entrance of subterranean channels or fissures worn out by water. From their capacity of carrying off water, drains are often made to terminate in them, and they afford a secure retreat to foxes. . . . . Having passed through limestone rocks, the water is usually *hard*, from the presence of carbonate of lime; many springs also contain more or less *iron*, as may be seen from the brownish-red deposit of peroxide of iron around them."[1]

The *Northampton Sand* (sand, sandstone and ironstone) has been a subject of controversy amongst geologists in the matter of classification, some classing it as the bottom division of the Lower Oolite, others as the top division of the Lias. For our purpose this is immaterial; it is enough for practical purposes that it comes between the Inferior Oolite limestone and the Upper Lias clay. It might here be grouped with the former, as there is nothing to prevent the passage of water from one to the other, probably though there is a difference of character in the water from the two beds.

In Huntingdonshire there is a trifling outcrop, like that of the Inferior Oolite and following it, in the bottom of the valley of the Nene at the north-western point of the county.

[1] "Geology of Rutland." Reprinted from White's History, Gazetteer and Directory (with Leicestershire) 1877, p. 67.

In Rutland, however, there is a long, winding, but for the most part very narrow outcrop, from north to south, as well as a number of outliers, one of which, at and around Uppingham, is large.

Collectively a large amount of water must be thrown out from this bed by springs at and near its junction with the Upper Lias clay.

Where the Lincolnshire Limestone rests direct on the Northampton Sand the two may form one water-system. This direct contact is shown in Rutland, none of the thin set of beds that sometimes comes between the two, the Lower Estuarine Series (more or less clayey) being shown on sheet 64 of the map. It is possible, however, that it may be thinly represented in places (too thinly to be mapped) and its occurrence has been suggested in the description of a well at Uppingham (*see* p. 115).

Marlstone Rock (*Lias*).

This calcareous, ferruginous, and sandy rock, is of no great thickness; but I think that Professor JUDD is mistaken in saying that it is "only 8 or 9 feet thick about Oakham,"[1] as a well there shows twice as much (*see* p. 113); moreover the large area it takes up at the surface there is hardly possible for a bed so thin as he described.

The main outcrop goes across the northern half of Rutland, from Teigh on the north to Egleton on the south, mostly of fair width, especially on the south, whilst there are narrow outcrops in the valleys of the Gwash, the Chater and the Eye Brook.

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[1] "Geology of Rutland," 1875, p. 65.

SPRINGS.

General Remarks.

Although springs are one form of the occurrence of water at the surface, yet, as their origin is from underground, and in some cases their water may have flowed a long way in its hidden course before coming to the surface, they cannot be disregarded in treating of underground water; they are indeed simply the points of outflow of such water.

They usually occur on slopes or in low ground where permeable beds are underlain by beds that are practically impermeable and that is the case in the three counties now dealt with, though there may be some springs of a less simple kind.

This is a subject on which information is much wanted, and it must come chiefly from local observers, a class as a rule somewhat rare where there is no local scientific society. As it is we must be content with such references as have been published or have been recorded by the few observers we know. The following few pages must therefore be taken as more or less of a sample, confined mostly to the best known occurrences, in stratigraphic order.

The interesting old records of mineral or medicinal waters will be given under a separate heading.

Jurassic Beds.

The character of the springs from the various water-yielding divisions of these beds is noticed in the Memoir on the Jurassic Rocks, Vols. iii, iv, v; but of specific reference to any ordinary (as distinguished from medicinal) spring in our district I have been able to find only the following, from Judd's "Geology of Rutland" (1875) p. 109.

"At Bisbrook the line of junction of the Northampton Sand and the Upper Lias is indicated by numerous springs." There must be many other occurrences, of which one would like to hear.

Cretaceous Beds.

The *Lower Greensand* is usually a formation from which many springs issue; but it is so thin and with so narrow an outcrop in Cambridgeshire that no record of any notable spring exists, though when pierced through the Gault it yields much water. It is the topmost member of this Series that is the chief source of springs in that county. In Huntingdonshire the Lower Greensand is for the most part hidden under Boulder Clay.

In the parish of Arrington, at its boundary with Wimpole, a spring is marked on the Ordnance Map (Cambridgeshire 53, N.W.) on the western side of the high road (Ermine Street) where it is joined by the road nearly three quarters of a mile southward of the village. The site is on Gault.

Chalk.

In Cambridgeshire there are many springs from the Lower Chalk, some thrown out at or near the base of the division, others from the Totternhoe Stone, a bed that marks the top of its lowest member, the clayey Chalk Marl, which holds up the water. Of the former set it has been written, presumably by W. H. PENNING, that the water held up by the underlying Gault "constitutes what is locally called the 'fossil spring,' from its occurring at or in the bed which encloses the 'coprolites.' This is the spring which prevents tunnelling for 'coprolites' being carried on with advantage."[1] So I take it that the term was used for the underground water found in borings.

In the following remarks the two sets of springs will be taken together, and the arrangement will be a topographic one, more or less from west to east; but dealing first with the long spur of Chalk, largely covered with Boulder Clay, which reaches many miles westward from Hauxton. Here a spring is marked on the Ordnance Map (Cambridgeshire 52, N.E.) about 8 chains W.S.W. of Croydon Church, just above the base of the Chalk.

At Orwell, eastward, three springs are marked on the map (Cambridgeshire 53, N.W.). One is near the schools and about 130 yards south-west of the Church and was flowing strongly in April 1910. W. W. GRAY noted, in September 1909, that there is here a dipping tank, 2 feet square, into which the water entered by an earthenware pipe, the quantity being about enough to supply a pipe of $1\frac{1}{2}$ inches diameter.

The second spring is at the back of the Red Lion, on the southern side of the street, half way to the third. Mr. GRAY noted that a circular brick pit of 2 feet diameter held $2\frac{3}{4}$ feet of water, which was used for a house and farm-buildings. There was a fair quantity of water rising.

Another spring is marked on the map, by West Farm, which happens to be at the extreme east of the village and at the eastern boundary of the parish. There was very little water here in September 1909. Mr. GRAY noted that in the ditch is a brick chamber, $3 \times 2\frac{1}{2}$ feet and 3 feet deep; it was about half full, and the water was chiefly used for the farm.

I saw all these springs, with Mr. GRAY. They are at, or only just above, the base of the Chalk.

At Little Eversden a spring is shown on the map (Cambridgeshire 46, S.E.) about 500 yards S.S.W. of the Church, also at the same geologic horizon.

A spring is shown on the map (Cambridgeshire 53, N.E.) a little eastward of the Royal Oak, at Barrington.

Coming to the main body of the Chalk we have a long line of springs, chiefly from the Totternhoe Stone, which has determined the sites of the many villages. Ruddy Spring is marked on the old map 46, N.E., at the outcrop of the Totternhoe

[1] "The Geology of the Neighbourhood of Cambridge," 1881, p. 129.

Stone on the county-boundary. This spot is in the parish of Guilden Morden, but about 1¾ miles southward of the village.

Thus we learn from the Report of the East Hunts. Water Co. of October 1893 that in the Bassingbourn District the chief springs are in two sets, one in the hollow eastward of the village at Kneesworth, and the other in that on the west (Wellhead to Church End). But besides these there are also springs in the tract between, in or close to the inhabited area. At the head of Westham Stream (? Wellhead) there are water-cress beds, and much work has been done in clearing out the abundant springs and stimulating their flow.

Of the Wellhead Springs, which rise in basins about two-thirds of a mile west of south from Bassingbourn Church, I have noted that many rise from pipes in the water which have been driven into the Chalk, here close to the surface. In the water-cress beds in two places a little way down the valley on the eastern side of the stream there were also pipes in the middle. Still lower down there seemed to be a spring on a side-stream on the other, or left, side of the valley about 380 yards W.S.W. from the Church.

I saw (many years ago) a good spring, roughly enclosed, some 560 yards S.S.E. from the Church, and another spring on the eastern side of the road just N. of E. The little stream above this is peculiar: in October, 1895, it was dry from about 930 to 1,030 yards from the Church, whilst just above (S.E.) there was water for some 80 yards.

About 1,400 yards east of the Church (and a little S.W. of Kneesworth) I saw another spring, with a small flow, in October 1895.

At Kneesworth springs are marked on the map (Cambridgeshire 58, N.W.) along the stream a little east of the Ermine Street. The highest of these, about 120 yards northward of the Ashwell Street (another Roman road), had but little water, with no apparent flow, on October 11th, 1895; but immediately to the north a small spring started, on the eastern side of the stream. Another set occurs W.S.W. of Kneesworth House.

Of these, Lord KNUTSFORD wrote to the Director of the Geological Survey in October 1918 to the following effect:—"The springs were evidently dug out many years ago (presumably to get a supply for the house). They rise at the bottom of pits 6 feet or more deep. The stream flows into a pond (not on the old 6-inch map), and between these are other springs, one of which is the largest on the estate, and always flows, whilst those first mentioned stop in August and September. There are also springs in the pond."

Sir A. STRAHAN wrote in answer that "the spring breaks out near the middle of the outcrop of the Lower Chalk. Several springs on the same geological horizon occur both east and west of Kneesworth. They are due to the existence of some marly bands in the Chalk which are impervious."

At Whaddon I saw a small spring at the corner of the road near the Vicarage (Cambridgeshire 53, S.W.). At Melbourn, what is clearly a spring-basin, at the head of the stream, is shown on the Ordnance Map (Cambridgeshire 58, N.E.) at Melbourn Bury, S.W. of the village; and a like occurrence is also shown some way to the east, by Black Peak, partly in this parish and partly in that of Foulmire. These are both well up in the Lower Chalk; the latter, indeed, may come from the Melbourn Rock, the base of the Middle Chalk, which is underlain by a marly bed. In Foulmire itself there are other cases southward of the Church (Cambridgeshire 59, N.W.).

Before going on to notice more easterly springs it seems well to interpolate here together a privately printed record of the levels and yield of several of the Chalk-springs. They are from p. 5, Reports on Evidence to be given in support of the Petition of the Cambridgeshire County Council against the Bills of the South Essex Water Board and of the South Essex Waterworks in the House of Lords, Session 1910.

The gaugings were taken on March 29th by Wm. Fox, and the levels by Harold Warren.

Melbourn Springs - -	77 feet above Ordnance Datum. 4,000,000 gallons a day.
Shepreth Springs - -	72 feet above Ordnance Datum. 4,400,000 gallons a day.
Thriplow Springs - -	75 feet above Ordnance Datum. 1,100,000 gallons a day.
Group of Springs between Thriplow and Whittlesford - - - -	71 to 74 feet above Ordnance Datum. 2,100,000 gallons a day.
Group of Springs between Whittlesford and Shelford - - - -	54 to 48 feet above Ordnance Datum.
Nine Wells (Great Shelford)	44 feet above Ordnance Datum.

There are signs of springs in the parishes of Hauxton and Little Shelford; but I am wanting in details. At Great Shelford there are springs by the road at the northern end of the village, opposite Granham's Farm.

The best-known springs of the county are probably those at Nine Wells, more than half-a-mile further northward, which start from the Totternhoe Stone, for their water once formed the supply of Cambridge.

The next noteworthy springs are at Cherry Hinton, where, at Springhead, a pond is formed by the springs, here also from the Totternhoe Stone, and forming the head of the Cherry Hinton, or Coldham's, Brook. The place is at the road-crossing at the southern end of the village, east of the house named Springfield, and the water is taken for the supply of Cambridge, being collected in two underground chambers of open brickwork. There is a boring about 6 yards from the pond, on its

eastern side, in which of course the water comes nearly to the surface, sometimes only about 9 inches down.

It is right to add that Professor T. McK. HUGHES held that the Cherry Hinton spring is fed principally from thin beds of stone in the Chalk Marl, below the Totternhoe Stone, the outcrop of which latter is further south than is shown on the Geological Survey map, and he marked his interpretation on a map in the Report of Dr. T. THOMSON and P. M. CROSTHWAITE to the Local Government Board, 1908. The reporters accept Professor HUGHES' view.

Along Caudle Ditch, which is in part the boundary between Fulbourn and Teversham, springs are marked on the old 1-inch map (51, S.W.), an unusual thing. But they are not shown on the 6-inch map of much later date. I saw one spring just north of Butcher's Farm, in the former parish. These springs would be about 500 yards north of the County Lunatic Asylum.

At Fulbourn the "Poor Well," just east of the waterworks, was a spring-pond. It is now dry (from the pumping at those Works), and the Water Company has given to the public, in its place, a cemented pond supplied from the works. In this parish the stream which starts (according to the map Cambridgeshire 48, S.W.) half-a-mile south of Home End, the extreme southern end of the village, is a bourne, or intermittent stream. In March 1910 there was a good flow just above the road to New Shardelowes Farm, whilst just below, in January 1909, it was dry, close to the road, and with very little water on the other side of the road. Lower down, some 260 yards N.E. of the road, I saw a spring.

One of the finest sets of springs in Cambridgeshire is known as Shardelowes Well, eastward of Fulbourn, and just within the border of the parish of Great Wilbraham. The highest spring is at the foot of the earthwork known as the Fleam Dyke, 57 feet above Ordnance Datum and about 120 yards southward of the so-called Well, and it is the head of the Great Wilbraham River. At the Well there are very many small "boiling springs," mostly in groups, rising up through the sandy bottom. About 100 yards lower down the stream, northward, where "Spring" is marked on the map (Cambridgeshire 48, S.W.), is another set of "boiling springs," breaking out a little east of the main stream, and immediately to the west is another spring. The source of the water of these springs is the Totternhoe Stone, or chiefly so, as is also the case with the two following.

At Little Wilbraham, close by the border of Great Wilbraham, there is a set of springs at and just north of Spring Plantation, forming the head of the New Cut, or Little Wilbraham River.

At Spring Hall, Bottisham, a mile eastward of the village, a stream which flows to the Swaffham Bulbeck Lode, starts from a spring pool, just west of the house.

In the parish of Burwell there is a spring from the Melbourn Rock a little north eastward of Burwell-heath Farm (Warbraham

Farm of the new map, on which the spring is not marked) and about $1\frac{1}{3}$ miles south-eastward from the church.

The stream that rises just south of Newmarket must start from springs at a higher horizon in the Middle Chalk.

From the above remarks it will be seen that the Totternhoe Stone is a great spring-horizon, and the authors of the Cambridge Memoir (p. 130) have duly recorded this. They say:—"The Totternhoe Stone at the top of the Chalk Marl holds the water that has percolated down to it through the overlying permeable chalk, as is shown by the line of springs which frequently follow its outcrop;" and F. R. C. Reed has alluded to this later, especially in reference to the eastern part of Cambridgeshire.[1]

Drift Gravel and Sand.

Where any of these highly permeable deposits rest on any of the clays, which are of such common occurrence in the three counties, of course the rain that falls on them must find some exit at or near the outcrop of the clays. But any springs thus formed are small, and generally it is perhaps the case that we find a line of dampness rather than any defined spring.

I have found no description of Gravel-springs in our district, and, indeed, were it not for the following notes from T. S. Dymond, which he sent me early in 1920, there would be nothing to say on this matter, except for some notes of so-called mineral springs.

The springs now to be noted are all in Huntingdonshire, and most of them in the Valley of the Ouse, between St. Neots and Huntingdon, and these come first.

"In crossing the Common from St. Neots to the Paper Mill (to the north) a sheet of water is passed, which has the appearance of a backwater to the river; but it has, I believe, no connection with the river. and is fed by springs (from gravel). At the far end of this sheet of water, close by the Paper Mills, a recent flood has produced a big hole, and disclosed a stream, previously underground."

"There is a spring at the Paper Mills, about a mile below St. Neots, which is used as a medicinal spa; but whether it has any medicinal virtue I know not." The water may come from the gravel, of which there is much there.

"At Great Paxton there is a good spring, which is used to supply water to the village."

"At Diddington there is a spring in the park." Both of these must come from gravel.

"At Offord the brook that flows past the school has its source in small springs." The source of these is not clear.

"There are some springs near the Mixed School at Brampton," and these again must be from gravel.

Turning to the valley of the tributary Ellington Brook, "there is a spring at Keyston, issuing from the fine gravel and

[1] "Geology of Cambridgeshire," p. 129.

sand which cover the clay there. Then there is said to be a spring at Molesworth, and at Leighton Bromswold there is a spring on the northern side of the hill."

"In the garden of the head-master at Somersham School there is an abundant spring, which formerly supplied the village with water. The house is part of the school-buildings." This too must be from gravel.

Mineral Springs.

There are certain waters which have a special interest from the fact that they have been taken to have a medicinal value, and have been used for healing purposes. In days long past more was thought of these waters than is now the case, and our information about them is chiefly derived from old publications.

There is, of course, no strongly-marked division between mineral and ordinary springs. All water contains some amount of mineral matter, and it is only when some of the mineral contents reach a certain (or rather uncertain) proportion that curative effects can be attributed to them.

Our records here are chiefly confined to Huntingdonshire, the other two counties giving us only one entry each, and one of those being only just outside Huntingdonshire. This is the case of Nill Well, on the boundary of Cambridgeshire, E.N.E. of Yelling Church (Cambridgeshire 37, N.W.), a chalybeate spring at the junction of the Boulder Clay and the Elsworth Rock.

At Little Castleton in Rutland (Ordnance Map 157, new series, Rutland 7, Geologic Map 64), there is *Tolethorpe Spa.* According to H. B. Woodward the water of this disused spa comes from the Lincolnshire Limestone ("Jurassic Rocks," vol. iv., 1894, p. 512); the site then must be in the bottom of the valley of the Gwash.

Coming to Huntingdonshire one occurrence has already been noted by Mr. Dymond (p. 29).

Hail Weston Spa is marked on the Ordnance Map (Huntingdonshire 25, N.E.), a little N.N.W. of Hail Bridge, on the county-boundary with Bedfordshire, by the words "Mineral Springs."

A. C. G. Cameron notes that the site is at a small re-entering angle of Alluvium into gravel.

The following remarks on the mineral waters of Huntingdonshire are from an old book by Dr. D. P. Layard, "An Account of the Somersham Water," 1767, pp. 7–11:—

"The county of *Huntingdon*, tho' one of the smallest, contains several springs of different kinds, some for common and others for medicinal purposes. Mr. Camden gives the earliest account of the Purgative Salt Waters at *Hail-Weston;* and a later writer, the anonymous compiler of *Magna Britannia Antiqua & Nova*, published in 1720, mentions that *St. Neot's*, and *St. Ives*, were famous for Medicinal Waters; but as no

springs of such a nature are found within the limits of those towns, they probably became noted by the residence of such persons who came to drink and use the purging *Hail-Weston* Waters . . . . . or by the concourse of those who came to drink the Chalybeate Waters on *Somersham Heath*." The site of this last, according to the Ordnance Map (on which the name does not appear), is in the parish of Bluntisham, close to its border with the parish of Holywell, and more than half a mile from the southern border of Somersham.

Our author goes on to mention "the pure and excellent water" of Huntingdon Horse Common (not named on the Ordnance Map 187) "the pure limpid spring in *Holywell* Church-yard, much more famed in superstitious times for its great purity than any medicinal property," and which would probably be condemned now as polluted; "the Chalybeate Waters of *Nill-Well*, or *St. Agnes's-Well* in *Papworth St. Agnes* (Cambridgeshire); at *Elton-Hall* [W. edge of the county] . . . . and other light Chalybeate springs rising in *Salome* wood, Huntingdon town," and "a very strong briny spring in a close . . . . at *Bury* near *Ramsey*."

Of Hail Weston he adds that it is "noted for there being three wells of different properties and uses very near each other."

The Somersham, or as it should be called the Bluntisham spring "issues forth from the declivity of a small hill, . . . on a heath," between St. Ives and Somersham, which, "was formerly covered by part of the royal forests, ... and now serves only for the grazing of sheep." It is not known when the water was discovered.

"Some having injudiciously drunk the . . . . Water while they laboured under a fit of the Stone or Gravel, which proved fatal to them; a report was spread that this Water was productive of the Stone; all that could be said in defence of the Water by the Physicians, upon the strictest examination, was to no purpose, the torrent of prejudice could not be stemmed; the spring became totally neglected, and so few persons continued the use of the Water, that the attendants' profits being very small, the house fell to ruin; and lest it should become a harbour for loose people, the materials were removed."

"However, a good opinion was still entertained of the . . . . Water, from its manifest success in many families. Physicians of great eminence . . . . made experiments on the Water, and agreed in their opinion of the utility of it in several cases, but could not discover the least property in the Water of producing either Stone or Gravel." In 1758 steps were taken to build another house.

Dr. LAYARD describes the water (p. 25) as "strongly impregnated with the vitriol of iron and allum. It is much stronger in dry than in wet seasons," presumably because of there being less water in the former.

Contrary to the usual custom he does not recommend the so-called Somersham water for every disease; but gives a caution against using it in certain cases (pp. 27, 30), for instance, whenever there are acidities in the stomach, vertigo, asthma, or by "such persons, who, through age or bulk, cannot take sufficient exercise, or have swelled legs."

In a paper of 1767,[1] Dr. LAYARD says of this place:—

"The different strata of the earth . . . are . . . first, about six inches depth of mould . . . then different strata of clay, each stratum about ten or twelve inches deep, growing darker from a yellowish or grey color to a dark blue golt the deeper it lies. At about seven feet deep is found a bed of gravel, out of which the water springs forth very clear . . . about twelve or fourteen inches thick, surrounded with a bed of very dark blue golt, beset with large quantities of selenites."

"The water, flowing from this spring, which is perennial, but runs more or less according to the different seasons, is received from the bed of gravel by three small brick channels, about two feet long, which meet in one of about six inches square. This channel which is near twenty feet in length, conveys the water to a bason also of brick, and about two feet square."

According to H. B. WOODWARD, the so-called Somersham Spa flows from a hard bed in the Oxford Clay; and he says that "Holywell, east of St. Ives, derives its name from a well in the churchyard: the water occurs in a bed of gravel that rests on the Oxford Clay."[2] In both cases the new map (187) makes it Ampthill Clay.

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[1] *Phil. Trans.*, vol. lvi., p. 26.

[2] "Jurassic Rocks," vol. v. (*Mem. Geol. Surv.*), 1895, pp. 339, 340.

CONTAMINATION AND RISK THEREOF.

General Remarks.

The mere getting of water from springs or by means of wells and borings is far from being the only consideration with which engineers and others are faced. It is of course essential that the water should be of good quality and therefore should come from an unpolluted source. Moreover, having got good water, it then becomes essential that it should be kept good, that pollution should not be allowed to arise; the source should be protected from risk.

In old times very often little care was taken in this matter: more or less polluted sources were used, and precautions were rarely taken to protect those which originally were unharmed. But more advanced views have gradually come to the front, and public water-supplies are often carefully guarded.

It is of some interest to look back on former conditions by which we may be helped in avoiding present or future evils, and also to notice cases where risks of pollution have had careful consideration in times not long past.

It is of course where permeable beds are at the surface that the risk of pollution is to be looked for. Where such formations are covered by impermeable beds there is local protection from surface-pollution; for instance, where, as has often been the case, the Lower Greensand has been tapped by boring through the overlying Gault.

In noticing the risk of pollution to which water in the Drift Gravels is open, the following remarks were written, presumably by W. H. Penning, in a Geological Survey Memoir that deals with part of our district.

"It is easy to understand that wells would be sunk in such deposits wherever a supply of water was required, or near each house in the towns and villages. But one fails to see why much should have been made of springs, where, through some local condition of the beds, water that has percolated through the gravel and sand of a graveyard is thrown out! Three such cases occur within our area (Map 51, S.W.), one at Hadstock, where the spring is enclosed by brick walls, and the water is highly esteemed by the villagers. It may be, however, that the difficulty of drawing and fetching water from the deep wells at the neighbouring farms has some influence on the meed of praise bestowed upon that from the spring."

"Another instance is at Somersham, where a brick arch, with an iron gate, has been in former times erected over a spring within the precincts of the old Bishop's palace. The palace has been razed, but the spring, with its protecting arch has been preserved. Yet it is inevitable that some at least of the water must have percolated through the gravel on which the adjoining graveyard stands."

"In an analogous case an arch has been erected over a spring and an inscribed brass plate built in, to hand down to posterity the name of the benefactor. The water here is thrown out at the junction of Oxford Clay with gravel, in a low corner of the churchyard at Holywell, and is therefore subject to peculiar risk of contamination."[1]

Local Cases.

In noticing specific cases where the supply of polluted water has been described, or where risk of pollution has been thought likely, a chronological arrangement will be followed.

It should be understood that the question of risk of contamination is often a controversial matter, and that the entry of a place in the following notes does not always imply that there is any serious defect in the water-supply of that place.

Ely.

The dangers of the state of the supply of water, in years long past, have been described by W. Lee in his Report to the General Board of Health of 1850, pp. 23–28, from his own observations and from evidence given.

He notes the following:—

Cases of wells and cesspools within 2 feet to 6 yards of each other.

An offensive ditch within 17 feet of houses, supplied from a well. Water of well polluted by an open cesspool 4 yards off.

Pump-well against the privy-cesspool.

He gives the following apt description of the kind of thing that held (in many places) of old: "This is the character of many of the wells in Ely, and the facts sufficiently prove the unsuitable character of the water from them. The supply of such wells is merely by percolation from the surface in the immediate vicinity. The rain-water, slops, fluid of cesspools, and all manner of refuse, soak into the soil, and converge by gravitation towards the nearest pump-well. As the water is pumped up, this process goes on until the interstices of the soil and subsoil all around become clogged and saturated with animal and vegetable refuse from the surface, and then the water in the well becomes polluted, and the supply diminished."

Wisbech.

W. Lee reported as follows to the General Board of Health in 1850: "I have not yet met with any town in a more lamentable condition as to the supply of water," and he gives instances of the difficulties that poor folk especially had in

[1] "The Geology of the Neighbourhood of Cambridge," 1881, p. 131.

getting water, and a long table (6 pages) of the sources of supply in many parts.

This is now past history, the town having a good supply of water brought from a long distance.

March.

In W. LEE's Report to the General Board of Health in 1851 it is said that the great amount of disease is attributed by the medical officers, H. WRIGHT and H. CARVER, to insanitary conditions, the water being got from surface or shallow sources.

The White Pump water was thought the best in the place; but it had 64° of hardness, whilst that from the gravel-pits by the railway-station had only 26°, and it was suggested that this source should be used for supply.

Whittlesey.

Sixth Rep. Riv. Poll. Comm., 1874, p. 409.

Obtains a supply from wells. On analysis of the waters two were found to be "exceedingly foul from the percolation of sewage. They were very dangerous waters. Samples from the Abyssinian pumps were much better, but cannot be recommended for domestic use. . . . All the samples were much too hard to be used for washing purposes."

For an analysis of the water *see* p. 131.

This is an interesting case of the liability to pollution of gravel-waters in an inhabited area. Presumably such wells are not now used.

For a somewhat like occurrence, *see under* **Somerby,** p. 143.

St. Neots.

The following is an example of the state of things that held in this small town before a public water-supply was provided. It is from the Report of the Medical Officer, T. POYNTZ WRIGHT, for 1886 and was reprinted in his Report for 1895, nothing having been done in the interval:—

"With regard to water, the present supply is entirely afforded from private wells sunk in the gravel. In the southern part of the town it appears that there is an intermediate [? overlying] stratum of clay, and the wells there may, possibly, yield better water than those in the other parts. The vast majority, however, being in gravel only, and of no great depth, are, necessarily, contaminated with anything that percolates into the subsoil, and pollutes it. Owing to the privy middens and cesspools existing here, and the proximity of them to the wells, the physical conditions surrounding those wells are such that pollution of all, or nearly all of them, is inevitable."

Fulbourn.

We now come to a very important modern case, and one which has been carefully investigated. The following notes are taken from the Report of the Local Government Board, No. 229, 1906.

"In May 1905, it came to the knowledge of the Local Government Board that a number of cases of enteric fever had recently occurred at the County Asylum at Fulbourn . . . ; and that several deaths had already taken place," and Dr. S. M. COPEMAN was instructed to inquire into the matter and to find out "what precautions were . . . adopted as to the disposal of the Asylum sewage with the object of avoiding possible danger of pollution of wells in the neighbourhood."

Major NORTON had already reported in 1902 on "the danger that exists of possible pollution to the Asylum wells and those of the Cambridge Waterworks Company by the discharge of untreated sewage from the Asylum direct on to land having a chalk subsoil and in close proximity to the water supplies above mentioned."

After the usual delays caused by the matter having been referred to the Town Council of Cambridge, to the Waterworks Company, and to the Commissioners of Lunacy, the last body wrote in October 1903 to the Visiting Committee of the Asylum on the subject, saying that "there is apprehension lest the water supply of the town of Cambridge should become contaminated by the sewage of the Fulbourn Lunatic Asylum."

"This apprehension seems to . . . . have substantial foundation, having regard to the facts that the Asylum sewage is dealt with by broad irrigation without previous treatment beyond screening, that the land on which it is distributed overlies a subsoil of chalk, which becomes fissured not far from the surface, and that the well of the Cambridge . . . . Waterworks is situate less than a mile from the Asylum."

It is added "that it is also highly desirable in the interest of the Asylum itself that the sewage should be treated before it is distributed on the land, seeing that the well from which the Asylum draws its supply of water is within a quarter of a mile of the area upon which the sewage is disposed."

Nevertheless, the Visitors did not admit the danger, and nothing further happened until the outbreak of enteric fever occurred in April 1905, and Dr. COPEMAN appeared upon the scene. We now take up the account of his investigation.

"The outbreak . . . . . apparently commenced in March last (1905), although, owing to the somewhat anomalous symptoms presented by many of the patients, ... the disease was, in the first instance, diagnosed as influenza"; but in April the occurrence of enteric fever was recognised.

Dr. ANNINGSON and Prof. WOODHEAD gave a Report to the Visiting Committee, 26th July 1905: "Up to the time that

their Report was issued 68 cases . . . . had been recognised, of whom 16 have died—a mortality rate of 23·5 per cent., but . . . . a few additional cases have since occurred."

"During the . . . . outbreak the average number of inmates was 615, which gives an attack rate of 11 per cent. and a mortality rate of 2·6 per cent. for the total number of persons."

They "entirely exonerated the water supply" as the cause of the outbreak, but they had a "strong conviction that the present method of disposal of the sewage from this large community might at any time become a source of real danger, not only to the inmates of the Asylum, but also to those using the Fulbourn water supply," with which Dr. COPEMAN agrees, and they hold that the initial cases were, perhaps, conveyed by milk.

After giving an account of wells and water-levels (noticed elsewhere), Dr. COPEMAN says: "The importance of the fact that the wells in Fulbourn village, in common with the deeper wells at the Waterworks and at the Asylum, all appear to derive their supply from one and the same underground 'lake' of water, obviously has relation to the possibility of specific contamination at any one point becoming a source of danger to the consumers of water obtained from any other situation in this area. But the fact that the daily abstraction of about 750,000 gallons . . . . at the Waterworks only causes a temporary and local depression of the water-level to the extent of about seven feet, while the raising of about 70,000 gallons a day at the Asylum brings about no appreciable lowering of the water surface in the well, affords evidence that the total amount of the underground water must be of enormous bulk, for which reason the occurrence of general specific contamination is rendered less probable than otherwise might be the case. But . . . . as the population of Cambridge increases there will arise the necessity for . . . . increase of the amount of water pumped from the Fulbourn area."

This made it important to get information as to the direction of flow of the underground water here and "records of the water-levels at the Fulbourn Waterworks well, at the Asylum well, and also at certain intermediate points" were found to show a "slight but gradual fall of water level from the Asylum well in the direction of the Waterworks, the cone of depression in the neighbourhood of the Waterworks well tending, no doubt, to become steeper during such times as pumping is in progress."

"With respect to the *direction of flow* of underground water in the neighbourhood of the Fulbourn Asylum, the general consensus of opinion as expressed to me by various informants locally, regards such line of flow as passing almost

directly from south to north, but as . . . . no sufficient reason for this opinion was forthcoming, it appeared desirable . . . . to obtain some experimental evidence," and thus "a means of estimating the likelihood, or the reverse, of possible contamination of water supplies as a result of the measures adopted in disposal of sewage on the grounds of the Asylum," eastward of the building, for which purpose "fluorescin, an aniline compound, the solution of which, even when enormously diluted, exhibits a brilliant green colouration," was used, after experiments had been made on the effect that chalk might have on that substance, and as to the permeability of the soil.

Samples of water were taken at various places around (?11); but distinct traces of fluorescein were found in two cases only, with "a suspicion of colour" elsewhere; but at a later date, a third locality was added (just east of the irrigation-area), and the water in the Asylum baths (a little west of the area) showed a green tinge.

This experiment was made with a solution of only 500 grammes each of fluorescein and sodium hydrate; but later a second one was made with 5 lbs. of fluorescein, and then "evidence of definite colouration was obtained, not only in the case of water from the Asylum well but also from the Fulbourn well of the Cambridge Waterworks Company. . . . ."

"It does not, of course, necessarily follow, because the presence of fluorescin should have proved capable of detection at various points . . . . at so great a distance in different directions, from the point at which it was introduced, that bacteria, harmful or otherwise, would be equally capable of transmission for so considerable a distance; but nevertheless the results of these experiments are decidedly instructive and important."

There is no plan of the original drainage-system of the Asylum. Recommendations were "made by the Architect to the Committee of Visitors from time to time, the majority of which . . . . have either been neglected altogether or modified before being carried into execution."

In 1903, however, the Architect "was called upon to provide a scheme for the necessary rearrangement of the drainage," and it was then found that the original system had been badly contrived, the drains badly laid, in subsidiary drains "joints were defective . . drain-pipes were broken, thus permitting leakage of the sewage into the ground . . which thus had gradually become contaminated along considerable lengths of the whole system." On applying the water-test to a main drain, with outlet blocked, it was "found that although water was pumped in continuously at full pressure from the engine house it was quite impossible to obtain any head of water at all in the drain, the water escaping into the soil as rapidly as it was pumped into the drains. Much of this water was

found to be making its way into the soil beneath the engine-house," so that the pollution could at any time reach the well.

After some delay a new scheme was put in hand in November 1904, and this was a decided improvement, "though the architect is undoubtedly correct in his contention that the scheme finally decided on by the Visiting Committee cannot be regarded as really satisfactory."

Dr. COPEMAN found that part of this new system was on "a most undesirable method," a drain having been "caused to empty into two previously existing and unventilated cess-pools . . . . which have not been in use . . . . for about twenty years;" they were "lined with cement to make them watertight, but they overflow into a 'swallow-hole' in the extremely pervious chalk, the bottom of which . . . . is only about 17 feet above the permanent water level. As the result of a test experiment carried out at my request, it was found practically impossible to fill this swallow-hole with water . . . . only about 150 gallons remaining in the hole at the end of a couple of hours notwithstanding that . . . . 12,000 gallons had been pumped into the hole." This drain was then cut off from the cesspools.

Of the sewage-disposal Dr. COPEMAN says: "Practically all the sewage of the Asylum is at present treated by the method of broad irrigation over grass land . . . . west and north of the Asylum," with some small exceptions. These sites are south of the burial ground (N.W. of the Asylum) and east of the gasworks, and therefore nearer to the Waterworks, the first being about 4 acres in size, the rectory-field, east of the Asylum, being abandoned.

After considering all the evidence, Dr. COPEMAN concludes as follows:—"The fact that so large an amount as 70,000 gallons of sewage has been disposed of daily on these irrigation areas, for some years past, without difficulty, affords obvious indication that, when once the upper layer of the soil has become thoroughly permeated, the liquid finds no difficulty in escaping along the fissured layers of the underlying chalk, where in course of time, as my experiments have shown, it must find access to the immense 'basin' forming the reservoir from which both the town of Cambridge and the Asylum itself derive their supply of drinking-water."

"Moreover, it is a well recognised fact that even a considerable layer of soil, when once thoroughly saturated, is no longer capable of acting efficiently as a bacterial filter; under which circumstances there would be afforded opportunity for the germs of typhoid fever or other infectious material, to be carried down along with the liquid portion of the sewage, thus rendering possible specific contamination of the water area."

"Although, fortunately, there is, up to the present, no definite evidence that danger to the community has actually arisen from this cause, ... it does not follow that the danger is not

one which may have to be reckoned with in the future, if such possibilities of continued pollution are not obviated."

It is therefore "undoubtedly incumbent on the Committee of Visitors to take measures . . . . with the least possible delay for providing a comprehensive and adequate system for the carriage and disposal of the Asylum sewage."

Commenting on Dr. COPEMAN's Report, Sir G. WOODHEAD, in a letter to the Waterworks Company of April 1906, says:—"So long as the filtering ground is unbroken I believe that the area is sufficient to deal efficiently with the amount of sewage (of the Asylum) that has hitherto been thrown on to it, but should a much larger amount of sewage be discharged or should the surface be broken, especially for the formation of cesspools, we have no guarantee that we shall continue to enjoy the same splendid water supply and our present comparative immunity from typhoid fever," and he objects to the present method of disposal of the sewage, as it might become a source of danger, both to the Asylum and to the Fulbourn works.

Cambridge.

It was not long after the issue of Dr. COPEMAN's Report on Fulbourn (*see* p. 36) that the whole subject of the water-supply of Cambridge was brought under discussion. Attention was drawn to it in February 1907, when W. L. H. DUCKWORTH drew up a statement entitled "Memoranda For the Meeting of Bursars and Stewards of Colleges" (3 pages, folio), in which it is said that there are "at least three possible sources of contamination:" the village of Fulbourn, the Asylum, and the village of Cherry Hinton.

This brought about a conference of Authorities in May, and an application in June to the Local Government Board to hold an inquiry, and one was duly held at Cambridge on February 18th and 19th, 1908, at which I was present, and the shorthand notes of which have been printed (128 pages, folio). There is no need however to go into details of the evidence given by Dr. ANNINGSON, F. BUNNETT, Prof. HUGHES, E. W. HARRY, G. E. MILLER, Dr. J. C. THRESH and Sir G. S. WOODHEAD, but it is enough to deal with the statements and conclusions of the Inspectors, Dr. T. THOMSON and P. M. CROSTHWAITE in their Report, dated October 1908, and made after "personal investigation of local conditions in the neighbourhood of the sources of the water supply."

Of the village of Cherry Hinton they say that "with the exception of two short lengths of sewer . . . . the village is unsewered. . . . . For the most part, slop sewage is cast upon gardens or yards, and, in such instances, is frequently thrown into a hole in the ground, which serves also as a receptacle for house refuse of all sorts. In some instances slop sewage passes to cesspools. The generally prevailing

conservancy system is the pail-closet, and the pail contents are commonly utilised for garden purposes. There are but two cesspit-privies in the village, and there are a few water-closets which drain to cesspools," many of which have been made watertight.

The throwing of house-refuse into holes, with slop-sewage, they speak of as "especially objectionable, and these 'guzzle-holes,' as they are locally termed, are unsightly and offensive."

Of the village of Fulbourn they say that the "sewers receive, in addition to surface water, some slop sewage and yard-drainage and also overflow sewage from certain cesspools. They discharge their contents, untreated, into ditches and streams. . . . . The majority of the houses . . . . however, do not drain to sewers; the prevailing custom . . . . being to cast slops on gardens or yards."

The sewage of the Asylum "is disposed of by broad irrigation over grass-land lying to the North and West of the asylum. There is no effluent . . . . the sewage is lost in the ground."

"It is evident . . . . that there is, in the neighbourhood of the Company's sources of supply, much and continuous fouling of the soil and subsoil by matters which, should they gain access to that supply, would involve grave danger."

The questions of the origin of the springs and of the direction of flow of underground water have been dealt with elsewhere (*see* pp. 15, 17–19, 27, 28).

Thirteen chemical analyses of the Company's water made in 1904 to 1907 "so far as they go . . . . reveal nothing unfavourable to the purity of the water; they are, however, too few . . . . to be of material value." . . . .

"On the other hand bacteriological examination of the water has been made, during the past nine years, with great frequency. Professor Woodhead, who has conducted these examinations . . . . stated . . . . that they are made from 250 to 270 times in the year." The water is examined with a view to ascertaining the number of bacteria in it, and has also, since the middle of 1906, been examined for the presence of bacillus coli communis.

Three charts are given showing the rainfall at Fulbourn, the number of bacteria found in the water in the years 1905 to 1907, and "the occasions on which bacillus coli communis was found present (in one centimetre of water)" to the number of 25 in 1906 and of 10 in 1907. We should not hesitate to say that these bacteria are too numerous and the occurrences of bacillus coli too frequent. The samples, however, were taken, not from the wells, but from taps in Cambridge; and it may reasonably be contended that "multiplication of bacteria would occur during the period of passage from well to water tap." Moreover, alterations and repairs of the Company's plant might lead to increase in the number of bacteria, and this

was the case. "In view of these considerations, we do not draw any inference from the numbers of the bacteria in the water supply. On the other hand, in as much as it is not to be presumed that the bacillus coli communis is likely to multiply in water, the not infrequent presence of this organism in the supply cannot well be explained by the multiplication theory and would therefore . . . . come to depend mainly on interference with water mains and the like."

As regards rainfall "in general, heavy falls of rain were followed by increase in bacteria in the water supply within two to four days," except in one instance.

"These charts do not indicate that rainfall is the only factor concerned with increase of bacteria in the water supply, but . . . . that heavy falls of rain are so commonly followed . . . . by notable increase of the numbers of bacteria . . . . as to be suggestive of causative relationship between the two conditions. This, in turn, would point to surface water gaining fairly rapid access to the sources of water supply." . . . .

"In six years only, during the period 1889–1905, did the death-rate from enteric fever in Cambridge exceed that for England and Wales," and as to the years "when the deaths from enteric fever were in serious excess, and . . . . when the persons . . . . attacked . . . . were unsatisfactorily numerous . . . . there is no evidence that these exceptional occurrences had relationship with the public water supply."

Passing to the consideration of the liability of the sources of supply to dangerous pollution, it is said of the village of Cherry Hinton, that "the water-levels of the wells . . . . indicate that the Company's spring, on the southern border of the village is fed, not only by water flowing to it from the south and south-east, but also by water flowing to it from the north and therefore from underneath the village. The description given of the sanitary conditions of this village leaves no room for doubt as to the amount of dangerous pollution it contributes to the ground on which it stands."

At Fulbourn the like holds, and there is also another risk from the sewers "which discharge crude sewage into streams or ditches," one of which "forms the southern boundary of the waterworks enclosure." The facts noted, considered with "observations of the flow of the water under the village towards the waterworks and the rapidity with which the levels of certain wells in the village were affected by pumping at the Company's station, indicate grave risk of pollution of their water supply."

It is then said "we are not inclined to the view that, under present conditions, the disposal of the Asylum sewage either on the present or on the suggested site would involve risk of dangerous pollution of the Company's water supply."

The conclusions are as follows, "that the continued use of that part of the Company's water which is derived from the Lower Chalk is, under present conditions, dangerous to the . . . . . community to whom it is supplied; and this notwithstanding the absence . . . . of evidence that the consumption of this water has been causatively associated with evil consequences in the past. . . . . It is, therefore, in our view, imperative that this water should be dealt with as unsafe for drinking purposes."

Allowing that "a good deal of improvement has recently been effected in the sanitary conditions of the villages of Fulbourn and Cherry Hinton," it is nevertheless judged that "measures that would effectually safeguard the Company's water against risk of dangerous pollution from the villages . . . . are not practicable."

After a short consideration of possible means for the removal or destruction of dangerous matter in the water (a subject on which much work has been done since the writing of this Report), it is said that "the whole of that part of the supply which is derived from the Lower Chalk should be abandoned."

Of course this would mean giving up by far the greater part of the water-supply, which, moreover, could not be replaced for a long time. The Company, therefore, after careful consideration of the case, put up experimental works at Fulbourn in May 1909, and on a large scale. These proved successful and showed that the process of chlorination gave a safe result. Since then chlorination has been greatly developed, and has been most satisfactory in many places, even with waters that were seriously polluted.

Ramsey.

In 1908 Dr. J. B. Wilkinson, the Consulting Medical Officer of Health to the County Council, reported on the prevalence of infectious disease in this Urban District, and dealt with the water-supply on pp. 13–15 of his Report.

The public supply was from the following sources :—

1. Pump in connection with the reservoir or ballast-pit formed by the excavation of clay for building, &c. Sides irregular, not lined. Much vegetable growth from the sides and a considerable amount of insect-life. The water came from a ditch, between grass-fields on the high land, which was dry at the time of his visit. This ditch was open to pollution, but the water was filtered through gravel. A notice on the pump stated that the water was unfit for drinking purposes without boiling. The analyses showed that the water was highly polluted with organic matter, there being as much as ·04 and ·03 grains per gallon of free and albumenoid ammonia respectively in August 1907.

2. Pumps in the town, at Bury Lane and on The Green. Notices on these stated that the water was unfit for drinking unless first boiled.

3. Pumps in outlying districts, at The Hearn, the Oil Mills, Forty Foot and St. Mary's, fed from fen-dykes, the water passing through gravel-filters.

4. Pump in the Great Whyte, the water from which is unfit for domestic use.

5. Many private pumps throughout the town, the water from all unfit for domestic use, though in some it was still used.

6. Rain-water, sometimes satisfactory, but mostly not.

"As far as could be ascertained there is an ample supply of water from all the pumps in the town, but all the wells are polluted and, in some instances, the water is little better than diluted sewage."

In reporting to the Local Government Board in 1909 Dr. R. D. SWEETING corroborates the above and says that the ballast-pit "still forms the chief supply of the town. It virtually contains impounded ditch water, gathered from ground liable to human and animal excremental pollution. There is some gravel filtration of the ditch water at its inlet into the 'pit,' and also some filtration through coarse sand and fine gravel and sand (6 feet in depth) before the water reaches an adjacent well to which a pump is fixed . . . . This 'pit' holds 700,000 gallons and is 10 to 11 feet deep." An appended analysis (by J. W. KNIGHTS) shows that the water is highly polluted.

The pumps in the town all draw "water from shallow wells sunk in the gravel, the depth of none of which exceeds some 15 feet."

"The foremost and most urgent need for Ramsey is a safe public water supply."

The above is an illustration of the difficulty of getting a public water-supply in a small town which apparently is far away from any water-bearing bed, except local gravel. An attempt to get water by boring through the Oxford Clay was unsuccessful, the water got being too salt for use (*see* p. 106).

SPRING SUPPLIES.

CAMBRIDGESHIRE.

In the town of Cambridge we have substantial records of a notable former supply from springs. J. W. CLARK tells us that "at the corner of Lensfield Road and Trumpington Road is the old stone Conduit, erected on the Market Hill in 1614, when a supply of fresh water was brought into the town from the springs of Nine Wells, in the parish of Shelford. This conduit was removed to its present position in 1855."[1]

In 1861 a monument was erected, by public subscription, to the Benefactors to the Watercourse and Conduit (T. CHAPLIN, 1610; Dr. S. PERSE, 1615; T. HOBSON, 1630; S. POTTS, 1806), and on the western side is the following inscription: "The supply of water to Cambridge from the adjacent springs was first suggested in 1574 by Andrew Berne, Master of Peterhouse. The design was revised by James Montague, Master of Sidney Sussex, and in 1610 carried into effect at the joint expense of the University and Town."

Carlton.

Ordnance Map 205, new series. (Cambridgeshire 49, S.W., 69, N.W.)
Geologic Map 51, S.E.

Dr. W. ARMISTEAD, Reports to the Linton Rural District Council for 1912–1914.

A public pump is supplied from a spring. Water is also got from ponds and wells.

Cherry Hinton.

Cambridge gets part of its water-supply from the spring in the Lower Chalk or Chalk Marl at Springhead (a name not on the 6-inch Ordnance Map) by the cross-roads at the southern end of the village. According to the Local Government Board Return of 1915, p. 181, the yield is 720,000 gallons a day, and more could be got.

Haddenham.

Ordnance Map 188, new series. (Cambridgeshire 29).
Geologic Map 51, N.W.

According to the Local Government Board Return of 1915 part of the parish is supplied from a spring in a gravel-pit at Aldreth, a hamlet a mile or more S.W. of the village. The average daily quantity of water got was 300 gallons and a further 200 could be got. The water is generally good, but rather hard.

Shelford, Great.

The Nine Wells springs here have been alluded to just above and on p. 27. They are conspicuous outflows, and their water forms a stream that

[1] "A Concise Guide to the Town and University of Cambridge, . . ." Small 8vo, Cambridge, 1904, p. 3.

flows through Cambridge. One of the founders of the former public supply to that place is the hero of the expression "Hobson's Choice." He certainly made a good choice of a spring-supply, which lasted for very many years; but has had to be given up, presumably from the growth of buildings on the course of the channel along which the water flows into the town.

According to the Local Government Return of 1915, Heydon gets its water from a spring (good), and Horseheath from a spring and pond (fairly satisfactory), whilst the following places get their supplies from wells and springs. Burrough Green (fairly satisfactory), Carlton-cum-Willingham (fairly satisfactory, *see* also above), Castle Camps (satisfactory in parts), Cheveley (not satisfactory), Coveney (satisfactory), Downham (satisfactory), Dullingham (fairly satisfactory), Hadenham (satisfactory, *see* also above), Harston (good), Hauxton (good), Meldreth (good and fairly adequate), Snailwell (satisfactory), Stretham (satisfactory), Thetford (satisfactory), Weston Colville (fairly satisfactory), West Wickham (fairly satisfactory in parts), Wilburton (satisfactory), Witcham (satisfactory), Witchford (satisfactory).

The Wisbech Waterworks Company gets its supply from springs in the Lower Chalk at Marham, in Norfolk (*see* Memoir on the Water Supply of that county, pp. 30, 54, 55).

Besides the town of Wisbech, it supplies a large tract of country, including the towns of Chatteris (part) and March, and the parishes of Doddington, Elm, Leverington, Manea, Outwell, Upwell and Wimblington in Cambridgeshire, as well as many others in Norfolk. This is the largest spring-supply taken by Cambridgeshire.

HUNTINGDONSHIRE.

Elton.

Ordnance Map 171, new series. (Huntingdonshire 4, N.E.)
Geologic Map 64.

Local Government Board Return, 1915, p. 279.

Col. D. J. H. PROBY supplies part of Elton from a spring from gravel, near Elton Mill. The quantity of water is adequate and the quality good.

Tetworth.

Ordnance Map 204, new series, (Huntingdonshire 27, S.E.)
Geologic Map 52, S.E.

Local Government Board Return 1915, p. 279.

Col. W. H. O. DUNCOMBE supplies parts of Abbotsley, Tetworth and Waresley from a spring (at Old Woodhay Farm), from sand, [Lower Greensand] on Tetworth Hill.

The supply is constant, and the daily average 2,000 gallons. The quality of the water is good.

According to the Local Government Board Return of 1915, Spaldwick gets its water from springs (good and ample), and the following places are supplied from wells and springs:—Brampton (fair and adequate), Buckworth (good and plentiful), Easton (good and plentiful), Ellington (good and plentiful), Sawtry All Saints and St. Andrew (good and sufficient).

RUTLAND.

The Local Government Board Return of 1915 gives us the following information.

Cottesmore, Exton and **Whitwell** (p. 598).

Ordnance Map 157, new series. Geologic Map 64.

The EARL OF GAINSBOROUGH supplies parts of the above parishes from springs from the Northampton Sand near the villages. The average daily quantity of water from each source is respectively 5,000, 7,500 and 3,000 gallons. The supply is adequate. The water is good and soft, but with no action on lead.

Empingham and **Normanton** (p. 598).

Ordnance Map 157, new series. Geologic Map 64.

The EARL OF ANCASTER supplies part of the former parish and the latter from springs from the Northampton Sand near the villages. The average daily quantity of water from each source is respectively 10,000 and 5,000 gallons. The Empingham water is filtered. The quantity is adequate, the water is good and soft, but with no action on lead.

The following places are noticed as getting their water from wells and springs:—Barrowden (unsatisfactory), North and South Luffenham (good).

Oakham gets an average daily quantity of 70,000 gallons from springs at Braunston (p. 207). *See* further on, p. 109.

WELL SUPPLIES.

Besides public supplies there are very many private ones, including those for factories, breweries, and institutions of various kinds. All these, of which notes have come to hand, are described further on (pp. 52–115); but in addition there are many villages and hamlets that get their water (or some of it) from a number of wells, mostly shallow, at houses and cottages or groups of cottages. Some of these have already been named under Spring Supplies, as they partly get their water from springs; but the following places are also dependent, or partly so, on wells, according to the Local Government Board Return of 1915, and are not entered under the heading Details of Wells, as we have no definite note of any well in them.

Cambridgeshire.

Abington Piggotts (good and adequate), Arrington (good and sufficient), Boxworth (fair), Brinkley (fairly satisfactory), Childerley (good), Chippenham (not very satisfactory), Little Chishall (good), Comberton (good), Croxton (indifferent, but sufficient), Croydon-cum-Clapton (fairly good and sufficient), Eltisley (good, but distant from some houses), Fen Drayton (fair), Fordham (not satisfactory), Little Gransden (good and ample), Guilden Morden (fairly good), East Hatley (satisfactory and ample), Kingston (very good and ample), Kirtling (fairly satisfactory), Kneesworth (good and adequate), Landbeach (good), Landwade (fairly satisfactory), Litlington (fairly good and adequate), Littleport Lode (not very satisfactory), Long Stanton St. Michael (good), Mepal (satisfactory), Newton (good), Oakington (good), Shingay (good and abundant), Steeple Morden (fairly good), Stow-cum-Quy (good), Sutton (satisfactory), Tadlow (very good and ample), Teversham (good), Thriplow (moderate and sufficient), Toft (very good and ample), Wentworth (satisfactory), Westley Waterless (fairly satisfactory), Westwick (good), Whittlesey (some fairly good), Great and Little Wilbraham (good).

Huntingdonshire.

Alconbury (good and adequate), Alconbury Weston (fair and adequate), Alwalton (satisfactory and sufficient), Broughton (fair), Buckden (fair and sufficient), Bury (fair), Caldecote (satisfactory and sufficient), Chesterton (satisfactory and sufficient), Colne (fair), Coppingford (fair and sufficient), Denton (satisfactory and sufficient), Diddington (fair and sufficient), Folksworth (not very satisfactory in dry seasons), Glatton (satisfactory and sufficient), Grafham (poor), Great Gransden (fair and sufficient), Haddon (satisfactory and sufficient), Hail Weston

(fair and sufficient), Hartford (indifferent, but plentiful), Hemingford Abbots and Grey (fair), Holme (satisfactory and sufficient), Holywell-cum-Needingworth (fair), Kimbolton (fair and sufficient), Midloe (fair and sufficient), Morborne (satisfactory and sufficient), Offord Cluney and Darcy (fair and sufficient), Little Paxton (fair and sufficient), Pidley-cum-Fenton (fair), Great Raveley (good and plentiful), St. Neots Rural (poor and indifferent), Sawtry St. Judith (indifferent and inadequate), Southoe (fair and sufficient), Stilton (satisfactory and sufficient), Stow (fair and sufficient), Great Stukeley (fair and sufficient), Little Stukeley (fair), Tilbrook (fair and sufficient), Toseland (poor and insufficient), Upton (fair and sufficient), Upwood (good and fairly sufficient), Warboys (fair), Washingley (satisfactory and sufficient), Water Newton (satisfactory and sufficient), Wistow (fair), Wood Walton (fair and sufficient), Woodhurst (fair), Woolley (fair and sufficient), Wyton (fair), Yaxley (satisfactory and sufficient), Yelling (fair and sufficient).

Rutland.

Ayston (good and generally sufficient), Barrow (fair and ample), Beamont Chase (good), Belton (good and generally sufficient), Bisbrooke (good and generally sufficient), Caldecott (good and generally sufficient), Great Casterton (good but limited), Little Casterton (good and ample), Clipsham (good and ample), Edith Weston (fair and ample), Egleton (fair and ample) Essendine (good and ample), Glaston (good and generally sufficient), Greetham (excellent and ample), Gunthorpe (fair and ample), Horn (fair and ample), Leighfield (fair and ample), Liddington (bad and generally insufficient), Lyndon (fair and ample), Manton (fair and ample), Martinsthorpe (fair and ample), Morcott (satisfactory but insufficient), Pickworth (good and ample), Pilton (satisfactory and sufficient), Preston (satisfactory and sufficient), Ridlington (satisfactory and sufficient), Seaton (satisfactory and sufficient) Stoke Dry (good and sufficient), Stretton (fair and ample). Teigh (fair and ample), Thistleton (fair and ample), Thorpe-by-Water (good and sufficient). Tickencote (fair and ample), Tixover (good and ample), Wardley (good and sufficient), Whissendine (fair and ample), Wing (good and generally adequate).

The three counties here dealt with do not possess any well of exceptional note, either on account of great depth or of very large yield; but many wells have a certain amount of geologic interest, notably perhaps in the matter of showing the depth to Lower Greensand, through Chalk and Gault. The following is a list of the more notable wells:—

In *Cambridgeshire* two wells (at Fulbourn and Meldreth) just reach a depth of 300 feet; seven are between this and 400 feet

(at Balsham, Cheveley, Graveley, Meldreth, Newmarket, Sawston and Stetchworth; one, at Cheveley, just reaches 400 feet, and two others exceed this, at Sawston (433 feet) and at Whittlesford (455).

In *Huntingdonshire* one well, at St. Neots, is said to reach the depth of 300 feet and another, at Ramsey, is 303 feet deep. A third, at Bury, the account of which came to hand whilst this Memoir was in the press, is our deepest record, 540 feet.

In *Rutland* wells or borings at Langham and Uppingham Waterworks are over 300 feet deep, and another at the latter place reaches 400.

It is singular that the second deepest boring, at Whittlesford, in Cambridgeshire, does not reach to the bottom of one of our latest geologic formations, the Glacial Drift.

The chief wells that have a geologic interest, from the information that they give as to the succession, character and thickness of the beds passed through, are as follows:—

Cambridgeshire.—Bottisham, Police Station (through to Lower Greensand); Cambridge (many wells through to Lower Greensand); Castle Camps Public Well (great depth of Boulder Clay); Cherry Hinton (several through into Lower Greensand); Cheveley, Stud Farm (thick Boulder Clay, 75 feet); Foxton (through to Lower Greensand); Fulbourn, Cambridge Waterworks (through to Lower Greensand); Graveley (through Boulder Clay and Oxford Clay to Cornbrash); March (note of fossils from Kimeridge and Oxford Clays); Sawston, the Woolpack (from Chalk through to Kimeridge Clay); Shepreth, Rhee Valley Cement Works (details of Chalk, Gault and Lower Greensand); Stretham, Chittering Farm (through Lower Greensand, Kimeridge and Ampthill Clays to Calc Grit); Thorney (through from Oxford Clay to Upper Estuarine Clay); Whittlesford, Railway Station (62½ feet of Drift) and The Cabin, with Glacial Drift not bottomed at 455 feet; Wood Ditton, Public Well 75 (feet of Glacial Drift).

Huntingdonshire.—Farcet (from thick Drift, through Lower Oolites to Lias); Ramsey (through Oxford Clay into Great Oolite?).

Rutland.—Uppingham Waterworks, reaching from Inferior Oolite to Lower Lias.

The following wells are of practical interest on account of the importance of the supply that they give, whether in regard to quantity or to object. Of course in counties without large towns, but few such occur.

In *Cambridgeshire*:—Bourn (E. Hunts. supply); Cherry Hinton (Cambridge Works); Cottenham (public supply); Fulbourn (Cambridge Works); Isleham (for Ely); Linton Rural District (for notes of water-levels); Meldreth and neighbouring villages, for borings into Lower Greensand, with overflowing water; Newmarket Waterworks.

In *Huntingdonshire* the only two notable works as regards supply are the very shallow ones of Huntingdon and St. Neots.

In *Rutland* the only well giving a large supply is that for Uppingham.

As far as I know no detailed account of the following wells has been published; they make their first appearance in print in this Memoir. Several small wells are not entered however, as of little importance in the information that they give.

Cambridgeshire.—Bartlow House, Cambridge (Falcon Ice Works, Leys School, Trinity College, University Press); Cherry Hinton (Cambridge Waterworks, No. 2, Norman and Saxon Cement Works, Swiss and another Laundry); Cheveley (for public supply); Foxton (Print Works); Fulbourn (Cambridge Waterworks); Newmarket (Lower Hare Park); Shepreth (Rhee Valley Cement Works); Shudy Camps; Thorney (Buke Horn Toll Farm); Great Wilbraham; also Sawtry (in Addenda).

Huntingdonshire.—Bury; Farcet and Wansford Public Supply

Rutland.—Barleythorpe, Essendine, Hambleton, Ketton, Langham Brewery, Ryhall and two at Uppingham Waterworks.

WELLS AND BORINGS IN CAMBRIDGESHIRE.

Abington, Great.

Ordnance Map 205, new series. (Cambridgeshire 55, S.W.)
Geologic Map 51, S.W.

Dr. W. ARMISTEAD. Reports to the Linton Rural District Council for 1912–14.

Wells in Chalk, from 20 to 240 feet deep. A pump near the school is used by the public. *See also* p. 80.

Abington, Little.

Maps and References as above.

Wells in Chalk from 15 to 122 feet deep. *See also* p. 80.

Ashley.

Ordnance Map, 189, new ser. (Cambridgeshire 42, S.E., 43, S.W.)
Geologic Map 51, S.E.

Three wells, from F. J. BENNETT'S notes.

1. Bocock's Farm.
   Gravel 12 feet
   Chalk 170 ,, } 182 feet.
2. In village. Made and communicated by WARREN of Bury.
   In Chalk, 150 feet.
3. A quarter of a mile S. of Windmill.
   Boulder Clay 4
   Gravel 4 } 8 feet.

Babraham.

Ordnance Map 205, new ser. (Cambridgeshire 54, N.E. 55, N.W.)
Geologic Map 51, S.W.

Worsted Lodge, Cottages.

Communicated by H. TOMLISON.

128 feet above Ordnance Datum.
Water stands 58½ feet from surface.
Chalk, 65 feet.

In his Reports to the Linton Rural District Council for 1912–1914 Dr. W. ARMISTEAD says that a public pump is supplied from a well in Chalk and other wells in Chalk are from 20 to 60 feet deep.

Balsham.

Ordnance Map 205, new ser. (Cambridgeshire 55 N.W. and N.E.)
Geologic Map, 51, S.W.

1. Parish Well.

Communicated by H. TOMLISON.

387 feet above Ordnance Datum.
Water stands 175 feet from surface.
Boulder Clay and Chalk, 275 feet.

Balsham, *cont.*

2 Public Well near the Schools, 1896.
Shaft, bricked for 50 feet. Made and communicated by G. INGOLD.
Water at 153½ feet.

		Thickness Feet.	Depth. Feet.
Made ground		2	2
[Boulder Clay]	Grey clay	3	5
	Brown clay	5	10
	Blue clay	30	40
	Brown clay	5	45
[Upper Chalk]	Chalk	25	70
	Hard clunch	2	72
	Chalk	29	101
[? Chalk Rock]	Very hard clunch	4	105
[Middle Chalk]	Hard chalk	50	155
	Hard clunch	1	156
	Chalk	3½	159½

JUKES-BROWNE notes the very hard bed as Chalk Rock with doubt.

3. Dotterel Hall, 2 miles N.W. of village.
Sunk 162 feet, the rest bored.
White Chalk with Greyish Chalk at bottom, 309 feet.

4, 5. (2 miles W. of) Gunner's Hall. 2 miles W. of village.
295 feet above Ordnance Datum.
At the Farm. Water stands 219 feet from surface.
Boulder Clay and Chalk, 229 feet.
At the Cottages, at a lower level:—
Chalk, 175 feet.

In his Reports to the Linton Rural District Council for 1912–1914 Dr. W. ARMISTEAD says that there are three public wells in Chalk (160,165 and 182 feet deep) and a shallow well in gravel and that there are private wells in Chalk or Gravel.

Barnwell, *see* Cambridge.

Barrington.

Ordnance Maps 204, 205, new ser. (Cambridgeshire 53, N.E.).
Geologic Map 51, S.W.

1. Coprolite Works, west of Church.
Four or five wells, varying from 70 to 125 feet in depth. In one the water overflowed, in others it stood at varying depths down to 25 feet.

2. Coprolite Works, three-quarters of a mile E. by N. of the Church.

Water overflowed.

Chalk Marl	15	200 feet.
Gault and Lower Greensand	185	

3. Doubtful site.

Communicated by N. W. JOHNSON.

Gault...	about 150	155 to 160 feet.
"Rock" and sand	5–10	

4. Trinity College Farm.
According to C. LACK, there is a well 25 feet deep, with a boring of 143. Total, 168; and the water was 4 feet down in 1908.

Bartlow.

Ordnance Map 205, new ser. (Cambridgeshire 60 N.E.)
Geologic Map 47.

Bartlow House. 1900.

Made and communicated by H. G. FEATHERBY.

180 feet above Ordnance Datum.
Well, 23 feet (top 5 feet bricked), then a bore of 6 inches diameter, top 100 feet lined.

Rest-level of water 22 feet down (?)

		Thickness. Feet.	Depth. Feet.
Chalk	Chalk	15	15
	Hard clunch	1½	16½
	Chalk	16	32½
	Clunch	12	44½
	Alternating layers of chalk and clunch. Thin bed of dark grey chalk 113 feet down	128½	173

According to Dr. W. ARMISTEAD'S Reports to the Linton Rural District Council for 1912–1914 wells in Chalk in Bartlow vary from 10 to 60 feet in depth.

Barton.

Ordnance Map 205, new ser. (Cambridgeshire 46, N.E. and S.E.)
Geologic Map 51, S.W.

1. A quarter of a mile N. of the Church.
Communicated by N. W. JOHNSON.

Shaft 55 feet, the rest bored.
Water to within 38 feet of the surface.

Chalk Marl	22	144 feet.
Gault	113	
Rock	9	

2. Clare College Farm.

New well, 1909. Close to the west of old well. Dug 51 feet, bored 94, total 145. Into Lower Greensand.
Water-level, 29 feet down.

3. Recreation Ground. About 1889.

Boring into Lower Greensand.
Fair supply, never known to have failed. W. W. GRAY, Feb., 1909.

Barway.

Ordnance Map 188, new ser. (Cambridgeshire 30, N.W. and N.E.)
Geologic Map 51, N.W.

Henney Hill. Just north of the farmyard, ? E. of the house.
Information from the tenant.

[Gault ?]	Clay about 4 feet.
	Clay and sand.
[Lower Greensand]	Black sand about 6 or 7 feet.
	To rock 27 feet.

Bassingbourn.

Ordnance Map 204, new ser. (Cambridgeshire 58, N.W.)
Geologic Map 47.

1. Coprolite Works, E. of Bleak Hall. Water overflowed.

Gault with a layer of phosphatic nodules near the bottom, about 115	About 120 feet.
Sand 3	
"Rock," hard, had to be punched through	

2. Doubtful site....

Communicated by N. W. Johnson.

Blue clay [Gault] to rock, about 150 feet.

3. An account of another well and boring 280 feet deep (? site) gives the figures, to top of Gault 40 feet. Gault 240, which seems excessive. Water rose above the surface (1879).

The village is supplied by the Royston Water Co. (Herts).

Bottisham.

Ordnance Map 188, new ser. (Cambridgeshire 41, N.W. and S.W.)
Geologic Map 51, S.W.

1. Police Station.

Communicated by W. M. Fawcett, County Surveyor, from information from the Contractor, Mr. Lack of Cottenham.

		Thickness. Feet.	Depth. Feet.
Made earth		2	2
[Lower Chalk]	Chalk marl	24	26
	Clunch	59	85
Gault (blue clay)		112	197
[Lower] Greensand		27	224

For an analysis of the water, *see* p. 118.

According to Mr. Lack, a boring here (presumably the above) is 236 feet deep, and the water-level in 1901 was 27 feet down.

2. Bottisham Fen.

Communicated by Mr. Flavell.

Black earth	4	142 feet.
[Chalk Marl], white clay	8	
[Gault and ? Lower Greensand], blue clay, rocks and sand	130	

Another version of this well is as follows:—

Dug down to coprolites	10	130 feet.
Bored through Gault and Greensand	120	

3. Bottisham Lode.

Communicated by Mr. Flavell.

Earth and white clay [Chalk Marl]	21	151 feet.
Blue clay [Gault], rocks and sand	130	

4. Bottisham Sluice.

Communicated by Mr. Flavell.

Black earth	5	125 feet.
Blue clay [Gault] to rocks and sand	120	

Bourn.

Ordnance Map 204, new ser. (Cambridgeshire 45, E. and 46, W.
Geologic Map, 51, S.W.

1. East Hunts Waterworks, close to Old North Road Railway Station, 1888?.

Communicated by M. FOLKES.

Shaft and cylinders 169¾ feet, the rest bored.

Water-level, 100 feet down; lowered 45 feet, by pumping at the rate of about 60 to 70 gallons a minute, in 1888. In 1896 only 28 gallons a minute pumped.

Boulder clay [probably includes Gault] ...	164	193 feet.
[Lower Greensand] Sand	8¼	
[?what] Soft blue clay	20¾	

If the clay be Kimeridge or Oxford Clay, the Gault must here cut down deeply into the Lower Greensand, or there must be a deep hollow of Boulder Clay.

An account from the Local Government Board gives the level as 117½ feet above Ordnance Datum, the depth of the shaft as 56 feet and that of the bore as 23, and the rest-level of the water as 96 feet above Ordnance Datum. When pumping about 8,500 gallons an hour, 74 feet—? a second well.

The Local Government Board Return of 1915 gives the average daily supply as 27,000 gallons, and 36,000 in bulk. To this 63,000 it is said that 70,000 could be added.

For analyses of the water see pp. 119, 120.

2. Near (3 miles S.S.W. of Elsworth).

Prof. H. G. SEELEY, "*Ann. Nat. Hist.*," ser. 3, vol. x., p. 100.

Hard blue clay with many *Ammonites*	84	150 feet.
Alternate bands of stone and sand with a layer of extremely hard grey-blue rock, full of shells, Elsworth Rock	14	
? Blue clay to bottom of well	52	

3. (? 3 miles S.S.W. of Elsworth), 1900.

Made and communicated by H. G. FEATHERBY.

116 feet above Ordnance Datum.

Rest-level of water 17 feet down. When pumping 10,000 gallons an hour lowered to 30 feet down, but keeps steady at that.

		Thickness Feet.	Depth Feet.
Boulder Clay	Brown clay	4	4
	Clayey gravel	1	5
	Blue clay with chalk stones ...	57	62
[?Lower Greensand]	Grey, yellow and green sand very lively	12	74
	Hard parting 2 inches. Coprolite-bed 10	1	75
	Green and grey sand ...	9½	84½
	Sandy clay	½	85
?Kimeridge	Stiff brown clay	1	86

Burwell.

Ordnance Map 188, new ser. (Cambridgeshire 35, S.E., 41, N.E.).
Geologic Map 51, N.W.

1. near Almshouses. 2. near the Bushell Beerhouse. 3. near Burnt Yard.

Communicated by JOHN BROWN, Rural Sanitary Inspector (1892).

1. 17 feet above Ordnance Datum. Shaft 5 feet. Water-level (April 1892), 10 feet above O.D.

Burwell, *cont.*

2. 25 feet above Ordnance Datum. Shaft 8 feet. Water-level 15 feet above Ordnance Datum. Yield 27 gallons a minute, with a six-inch pump.

3. 18 feet above Ordnance Datum. Shaft 7 feet. Water-level (April 1892), 11½ feet above O.D.

		1. Feet.	2. Feet.	3. Feet.
Alluvial soil		3	2	2½
[Lower Chalk.]	Top clunch, loose, soft, easy boring	11½	34	16½
	Close white chalk or clunch, very hard boring	21½	14	21
	White chalk	—	touched.	—
Gault		4	—	touched.
	Total	40	50	40

4. W. Colchester told me (1892) that in the garden of his house a boring reached the Lower Greensand at the depth of "about 150 feet, of which 60 feet was through Gault. We have a plentiful supply of good soft water." The thickness assigned to the Gault seems, however, to be too small, and perhaps the upper part of that formation was mistaken for Chalk Marl.

Caldecote.

Ordnance Map 204, new ser. (Cambridgeshire 46, N.W.)
Geologic Map 51, S,W.

Mr. Westrope's.

Sunk 27 feet, the rest bored.
Water stands 17 feet from the surface.
Gault (? and Boulder clay), 67 feet.
The bore-hole ends in the top of a hard rock.

Cambridge.

Ordnance Maps 188, 205, new ser. (Cambridgeshire 40, S.W., S.E., 47 N.W., N.E.). Geologic Map 51, S.W.

An early reference to the water-supply of this important town and university was made by no less a person than William Smith, who, in No. 5 of his Geological Sections, 1819, says: "On the Castle Hill and in the City three Wells have been recently sunk through the Golt 140 feet deep, which overflowed."

A long past condition of things in the water-supply of the town has been recorded by W. Ranger, in his Report to the General Board of Health of 1849, from which the following remarks are taken (pp. 14, 15):—

"One of the sources from which water is collected for domestic use in the town is land-springs, derived from the permeable nature of the surface-soil, which rests on an impermeable stratum of clay, the geological position affording a natural filtering bed. The water itself is within reach of common suction pumps, the wells [in the gravel] varying from 15 to 30 feet in depth."

"A second source of supply is . . . . about four miles from the town, called the Nine Wells, and set apart for the special purpose by the Shelford Enclosure Act. These waters unite in one stream, and are conducted to the town by Hobson's Conduit. . . ."

"A third source is the Artesian wells. . . . . Mr. Deck observes, the first bore was made in 1804; subsequently bores have been made at the new buildings in King's College, at Corpus Christi, and other places; but the chalybeate quality of the water renders it nearly useless." . . .

"The other source to be noticed belongs to Trinity College; this rises in a bed of gravel west of the Observatory, and is conveyed to the college

Cambridge, *cont.*

through St. John's College grounds, and from thence through the fields in a direct line to the Conduit . . . . on the Madingly-road, about 1½ miles from the college; its altitude is sufficient to supply the upper parts of the building, the college having laid down a supply-pipe for public convenience. Many parties avail themselves of the means thus afforded for a supply of water."

"Notwithstanding there is a plentiful supply of water constantly flowing into the town . . . . yet in numerous instances I found large numbers of the poorer class . . . . who do not participate in the benefit derivable from either source," and he notes very many cases of failure of supply. He advocates the further use of the Nine Wells springs (p. 18).

Since then many borings have been made, largely for the coprolite-workings, and in 1865 Prof. D. T. ANSTED, an old Cambridge man, said: "The wells at Cambridge are very numerous, and penetrate the gault to the lower greensand at a depth of from 100 feet to 150 feet. The cost is very small, and the supply at first rose to or above the surface. It is now 10 or 12 feet below. The supply is large and steady, and the number of wells within a few square miles amounts to several hundred."[1]

Very many such wells were described in the Memoir on the Geology of Cambridge in 1881, all of which of course are now reproduced and accounts of many others are added.

1. Messrs. Bailey and Tebbutt.
   Made and communicated by C. LACK.
   Well 28 feet, boring 127, total 155.
   Water (from Lower Greensand ?) 14 feet down, in 1897.

2. Messrs. Barker and Sons.
   Made and communicated by C. LACK.
   Well 50 feet, boring 104, total 154.
   Water 24 feet down in 1896, 43 feet in 1909.

3. Barnwell. The large Brickyard.
   Communicated by Mr. LEE.
   Shaft 20 feet, the rest bored.

[Chalk Marl] Soil and white clay	10	160 feet.
[Gault] Blue clay	150	

4. Bateman Street, Mrs. Headley's.

[Chalk Marl] Soil and clunch	16	136 feet.
[Gault] Blue clay, to Greensand and water ...	120	

   Another account makes the Gault 160 feet thick.

5. Messrs. Bird and Sons.
   Made and communicated by C. LACK.
   Well 24½ feet, boring 110½, total 135.
   Water rose to ground-level in 1896.

6. Botanic Gardens.
   Made and communicated by C. LACK.
   Well 50 feet, boring 119, total 169.
   Water 23 feet down in 1903.

7. Castle Soap Works.
   Made and communicated by C. LACK.
   Well 50 feet, boring 92, total 142.
   Water 37 feet down in 1908.

8. Cemetery.
   Gault to rock 130 feet.

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1 "Applications of Geology to the Arts and Manufactures." Small 8vo, London, p. 71.

Cambridge, *cont.*

9. Chesterton. Junction Station, Great Eastern Railway. 1890.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 10 feet 10 inches down (May).

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)		—	66
[Gault] Light-coloured hard clay		62	128
[Lower Greensand]	Green sand	9	137
	Clay and sand	2	139
	Stones	3	142
	Sand and stones	8	150

10. Chesterton.

Communicated by N. W. Johnson.

[Valley Drift] gravel and sand	10	123 feet.
[Gault] blue clay	105	
[Lower Greensand] rock and sand	8	

11. Coldhams Common.

Communicated by Mr. Flavell.

[Chalk Marl] soil and marl	27	157 feet.
[Gault] blue clay	120	
[Lower Greensand], clayey sand and "rock"	10	

12. Coldhams Common.

Communicated by Mr. Coe.

[Chalk Marl] soil and marl	18	125 feet.
[Gault] blue clay	107	

13. Coldhams Common. Coprolite-works on northern side.

Communicated by the Foreman.

Chalk Marl	10	130 feet.
Blue clay (bored)	120	

14. Coldhams Common, N. side.

Communicated by Mr. Lee.

[Chalk Marl] white clay	10	140½ feet.
[Gault] blue clay	130	
Rock	½	

15. Coldhams Common. Coprolite-works, a quarter of a mile S. of.

Communicated by Mr. Coe.

		Thickness. Feet.	Depth. Feet.
[Chalk Marl] grey and blue marl		23	23
[Gault]	Blue clay	110	133
	Dark clayey sand and coprolites	6	139
[Lower Greensand] hard rock		11	150

16. Coldham Lane Laundry.

Made and communicated by C. Lack.

Boring 130 feet deep. Water 12 feet down in 1902.

17. Coprolite Works near the Observatory.

Communicated by the Foreman.

Gravel	12	144 feet
Chalk Marl	12	
Gault, to rock	120	

Cambridge, *cont.*

18. East road and New Town generally, the wells are, as below.

Communicated by Mr. COULSON, Builder.

Gravel	... 10 to 20	145 to 160 feet.
Gault	about 130	
Sand and rocky beds	5 to 10	

19. Mr. Edwards' Brewery.

Made and communicated by Messrs. ISLER & Co.

Water-level 18½ feet below the surface in the bore tube.
Supply, 500 gallons a minute, with hand-pump.

		Thickness. Feet.	Depth. Feet.
Well, the rest bored		—	5
Gravel		6	11
[Gault]	Gault [clay]	123	134
	Rock	1	135
[Lower Greensand]	Dead greensand	4	139
	Rock and sand	2	141
	Rock	6	147
	Sand	13	160

20. W. M. Fletcher's.

Made and communicated by C. LACK.

Well 26 feet, boring 87, total 113.
Water rose to the surface in 1907.

21. Hills Road, Mr. Thoday's.

Communicated by Mr. FLAVELL.

[Chalk Marl] soil and clunch	20	200 feet.
[Gault] blue clay	160	
Black sand and rock	20	

This well is exceptionally deep, and Mr. THODAY states that alternations of hard and soft beds were met with below the Gault. The thickness of the latter is also doubtful.

22. Histon Road, Stokesay Laundry.

Made and communicated by C. LACK.

Well 50 feet, boring 82, total 132.
Water 33 feet down in 1907.

23. Leys School.

From J. C. ISARD, Bursar (1909).

Originally bored some 20 years ago, a 4-inch bore being driven to a depth of about 200 feet. Through this a good constant flow of water was got at first, keeping the well-shaft (20 feet deep) nearly brimful, the water sinking only 5 or 6 feet in the course of some hours' continuous pumping at the rate of 4,000 gallons an hour.

In the course of time the supply became more and more scanty and tardy, so that in the last two or three years (= 1907–9) it has been necessary to draw from the bore, in order to ensure against the pumps drawing in air, notwithstanding the addition of a 6-inch bore alongside the other. Even when not pumping the water is hardly as much as 6 feet deep in the shaft.

The water is said to come from Lower Greensand, beneath a layer of rock a few feet thick.

24. Newmarket Road. Mr. Wortley's, 1907. W. W. GRAY writes (1909) that a boring made here, into the Lower Greensand, is now dry.

Cambridge, *cont.*

25. Petty Cury, Falcon Ice Works.

Information from W. W. Gray, from a drawing communicated by Messrs. Baily, Grundy and Barrett.

	Ft.	in.	Ft.	in.
Soil	6	4	120	8
Gravel	8	9		
Gault	105	7		

Total 120½, presumably to Lower Greensand.

Water-levels:

	Depth. Ft.	ins.
Inside bore 17th August 1906	10	11
Inside bore 17th August 1906 pumping	24	0
Outside bore 17th August 1906	12	7
Inside bore 6th February 1909	19	2
Inside bore 7th February, 1909 (pumping about six hours a day)	31	10

The rate of pumping was 6,000 gallons an hour.

Cylinders of 5 feet diameter 4 ft. 7 ins.; cylinders of 3 feet for 12½ feet, then brickwork, opening out to 5 feet, diameter (inside) for 33 ft. 7 in., then a boring of 6 inches diameter, with pipe up to 4 feet above bottom of well.

The men were working in the bottom of the well, when water rose up quickly from the bore-hole and nearly drowned them.

26. Railway Station.

Communicated by Mr. Flavell.

Shaft 60 feet, the rest bored.

Gravel and clunch...	20	140 feet.
Gault, with coprolites, at 40 feet down	120	
Sand, a few feet	—	

Another well given as at the railway, probably at Mill Road level-crossing, passed through—

Gravel	6	156 feet.
[Chalk Marl] white clay	20	
[Gault and Lower Greensand] blue clay, rocks and sand	130	

Railway Station. In the Yard of Messrs. Foster & Co., Corn Merchants.

Communicated by W. M. Fawcett, County Surveyor, from information from the contractor, Mr. Lack, of Cottenham.

Yield, 6,000 gallons an hour, pumping continuously.

	Thickness. Feet.	Depth. Feet.
Made earth (soil and gravel)	13	13
[Chalk Marl] { Chalk Marl (blue and grey) ...	4	17
[Chalk Marl] { Clunch	32⅔	49⅔
Gault (Blue clay)	130⅓	180
[Lower] Greensand	28	208

27. Tenison Road, Messrs. Arnold and Tupling.

Made and communicated by C. Lack.

Well 50 feet, boring 163, total 213 ?

Water 30 feet down in 1899, 44 in 1909.

28. Trinity College, on the northern side of the Chapel, 1907.

Made and communicated by Messrs. Isler & Co. and from W. W. Gray.

Lined with 30 feet of tubes of 7¼ inches diameter from 4 feet down and 130 feet of 6 inches diameter from 2 feet down.

Cambridge, *cont.*

Water-level 15 feet down. Pumped to 26. Pumping 5,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil		13	13
[River Gravel] Ballast		2	15
Gault		100	115
[Lower Greensand. 39 feet]	Dark sand	2	117
	Light-brown sand	12	129
	Brown or green sand	10	139
	Sand-rock	1	140
	Green sand	14	154
Black [Kimeridge] clay (or layers of clay and rock)		73	227

29. University Press Buildings.

Made and communicated by C. Lack, of Cottenham.

Shaft 65 feet (in a kind of cellar about 6 feet below ground-level), lined with brickwork in cement. Then a boring of 6 inches diameter, with tubes 58 feet down, from the bottom of the well.

Water-level about 19 feet down the well.
To cellar floor, about 6 feet.
Mixed soil and stones, 6 or 7 feet.
Blue Gault.
Lower Greensand reached at about 127 feet below ground-level.

30. For Mr. W. Warboys.

Made and communicated by Messrs. Isler & Co

Supply 900 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)		—	14
[Gault]	Gault	132	146
	Gault with sand	7	153
[Lower Greensand]	Rock	10	163
	Greensand	5	168

31. Downing Site. About 80 yards south of the south-eastern corner of the School of Agriculture.

Well made during the War.

Prof. J. E. Marr, *Quart. Journ. Geol. Soc.* 1920, vol. lxxv, pp. 224, 225.

Unfortunately the thicknesses of the beds are not given, and the drawing is to the awkward scale of 3 feet to an inch.

The well was made to supply some allotments; but it yielded no water.

Warp [soil ?]		1	
[River Drift]	Stalagmite	¼ to ¾	To Gault 15½ feet.
	Reddish sandy loam, shells close to top	nearly 1 to over 4	
	Coarse ferruginous gravel ...	2 to over 5	
	Grey clay, with sandy partings. Shells close to top. Gravel seam in lower part	1½ to over 2	
	Fine ferruginous gravel... ...	¾ to over 1¼	
	Fine grey gravel...	over 1 to 2	
	Slightly ferruginous gravel ...	¼ to over ¾	
	Grey clay, sandy at base, shells near bottom	about 1	
	Grey gravel with boulders ...	up to nearly 2	

University and Town Waterworks Company.

The following information from the Local Government Board Return of 1915, pp. 181–182.

Established 1853. Supplies also Cherry Hinton (Part), Coton, Fen Ditton, Fulbourn, Girton, Grantchester, Great Shelford, Histon, Impington, Madingley, Milton, Teversham and Trumpington.

Daily average supply 1,841,000 gallons. Supply constant.

Quarterly examinations of the water are made. Chemically the water is of most excellent quality and bacteriologically it is good (July 1913). Hardness 17·79°, of which 3·29° is permanent.

According to the *Water Works Directory*, 1911, the population supplied was 69,000.

See *Cherry Hinton* and *Fulbourn*, for Wells and Springs used.

Castle Camps.

Ordnance Map 205, new ser. (Cambridgeshire 61, N.W.) Geologic Map, 47.

1. Public Well, 1896.

Shaft, Made and communicated by G. Ingold.

Water at 115 feet.

		Thickness. Feet.	Depth Feet.
Made ground	... ...	3	3
[Boulder Clay]	Blue clay	3	6
	Yellow clay	4	10
	Brown clay	7	17
	Chalky rubble	6	23
	Blue clay	62	85
	Light-grey clay	5	90
	Hurrock (chalky rubble) ...	2	92
	Blue and light-grey clay ...	26	118
	Hurrock (chalky rubble) with water	2	120

2. Boring by roadside, near Malting. 1884.

Made and communicated by G. Ingold.

		Thickness. Feet.	Depth. Feet.
[Boulder Clay]	Yellow clay	4	4
	Blue clay	7	11
	Blue sandy loam	7	18
	Blue clay; hard layer of flints at 27 feet	22	40

3. Information from G. Ingold.

Shaft 140 feet, bore 64 feet. 10 feet of water in shaft.

To Chalk	40	204 feet.
Chalk	164	

4. Shaft 154 feet, the rest bored.

Gravel	7	184 feet.
Clay	13	
Chalk	164	

According to Dr. W. Armistead's Reports to the Linton Rural District Council for 1913, 1914, springs and ponds are also used for supply.

Chatteris.

Ordnance Maps 172, 173, new ser. (Cambridgeshire 20, E., 21. W., 24, 25, W.) Geologic Map, 65.

See under Welche's Dam, p. 95.

Cherry Hinton.

Ordnance Maps 188, 205, new ser. (Cambridgeshire 47, N.E.)
Geologic Map 51, S.W.

1. Cambridge Waterworks. Originally 46 feet; deepened 1875.
About 35 feet, above Ordnance Datum

Communicated by H. TOMLISON.

Shaft to the Gault, the rest bored.
Water within a few feet of the surface.

		Thickness. Feet.	Depth. Feet.
[Chalk Marl, 48 feet]	Soil and light-coloured marl ...	6	6
	Darker clunch	23	29
	Light-coloured clunch or marl	7	36
	Greyish chalk	4	40
	Blue clunch with coprolite-bed at bottom	8	48
Gault, Slate-grey clay, with a band of small grey coprolites 33 feet from the bottom ...		125	173
[Lower Greensand]	Brown clayey sand, with ferruginous phosphate-nodules at bottom, and a hard rock below	2	175
	Soft brown sand with water ...	1	176

2. Cambridge Waterworks. No. 4 Well, 1884.

Communicated by W. W. GRAY, Engineer to the Co.

Telescope Well, with small bore. Bigger bore in No. 4.

		Thickness. Ft.	in.	Depth. Ft.	in
[Soil] Earth		4	6	4	6
[Chalk Marl, about 42 feet]	Grey clay	5	3	9	9
	Light-grey clunch ...	19	6	29	3
	Very light-coloured clunch	2	9	32	0
	Grey chalk	6	0	38	0
	Grey chalk with sand and fossils	7	8	45	8
	Upper Greensand and fossils [base of Chalk Marl]	1	0	46	8
[Gault, 124½ feet.]	Blue gault	1	4	48	0
	Hard blue gault	62	11	110	11
	Light-blue gault	4	3	115	2
	Very tough blue gault ...	45	1	160	3
	Dark gault and rough yellowish clay and sand	10	11	171	2
[Lower Greensand, 30 feet.]	Green sand	6	5	177	7
	Soft green sand	1	3	178	10
	Hard green sand		3	179	1
	Soft running green sand...	2	9	181	10
	Rock and sand	6	9	188	7
	Dark green sand... ...	4	0	192	7
	Very dark green sand ...	8	8	201	3

The 3 inches of hard green sand at 179 feet is the only coarse sand, all the rest is fine. More water met with at 198 feet than at the further depth of 3 feet.

Well in Chalk. Water-level at rest 28·3 feet above Ordnance Datum. When pumping 5 feet.

Cherry Hinton, *cont.*

Bore in Lower Greensand, water-level at rest, 6 feet above Ordnance Datum. When pumping, 27 feet below Ordnance Datum. The figures from a letter to the Local Government Board on 27th February 1914.

According to Dr. COPEMAN'S Report (1906) there are four pumping wells, 40 feet deep, and water is piped to these from the spring-head (*see* p. 27). All four are connected. Average daily amount pumped, 800,000 gallons, of which about 200,000 is believed to be from the Lower Greensand.

It is said by Dr. FORBES and E. W. HARRY (in a Report to the Borough, 1907) that the lowest inlets to the wells, apart from the bore, are only 1¾ feet above the Gault. The Report by Dr. THOMSON and P. M. CROSTHWAITE (1908) makes all the wells 48 feet deep, and one is not watertight. The average daily amount then pumped was 843,000 gallons.

For analyses of the water, *see* pp. 121, 122.

3. Nether Hall (1⅝ miles S.W. of the Church).

Made and communicated by G. INGOLD.

Shaft 32 feet, the rest bored. 1893, 94.

Water rose to within 40 feet of the surface. Plentiful supply.

		Thickness. Feet.	Depth. Feet.
Soil		4	4
[Lower Chalk]	Hard, loose clunch	41	45
	Chalk marl	44½	89½
	Coprolite-bed	1¼	90¾
[Gault, 142½ feet]	Gault	136¼	227
	Hard, green, sandy clay	2	229
	Black, sandy clay	4¼	233¼
[Lower Greensand, 50¾ feet]	Hard, rocky greensand	7	240½
	Rock, very hard	1¾	242
	Sand	2	244
	Rock, very hard	1¼	245¼
	Hard sand	2¾	248
	Sand, changing from light to dark green	36	284

4. Seventy yards N.E. of 3. Shaft 20 feet, the rest bored. 1893.

[Lower Chalk]	Clunch	82 feet	92 feet.
	Chalk marl		
	Coprolite-bed	10 inches	
Gault		9 ft. 2 in.	

JUKES-BROWNE remarks that both sites are above the outcrop of the Totternhoe Stone, as drawn on the published 1-inch map (51 S.W.).

5. Norman Cement Co., 1903.

Made and communicated by J. E. NOBLE.

A boring of 8 inches diameter.

A good supply of water from the Black sand, standing from 29 to 26 feet down (for 600, 250 and 60 Horse-power Engine and other purposes).

		Thickness. Ft. ins.	Depth. Ft. ins.
Soil		2 0	2 0
Chalk marl		28 9	30 9
Hard grey sand		20 5	51 2
[Gault] Clay		132 9	183 11
[Lower Greensand]	Sandstone	6 0	189 11
	Rock	2 0	191 11
	Sandstone	6 0	197 11
	Black sand	31 9	229 8

Cherry Hinton, *cont.*

6. Saxon Cement Co. 1900.

On the west of the railway, south of Coldham Lane.

Made and communicated by J. E. NOBLE of Thurlby.

A boring of 6 inches diameter.

A good supply of water from the [bottom ?] green sand, standing 36 feet down.

		Thickness. Feet.	Depth. Feet.
Soil		2	2
Chalk marl		32	34
[Gault]	Blue Gault	61	95
	Clay	67	162
	Green sand	4	166
[Lower Greensand]	Ironstone [iron-sandstone ?]	5½	171½
	Hard sand	17½	189
	Green sand	24	213

7. Swiss Laundry. 1910.

Made and communicated by Messrs. DUKE AND OCKENDEN.

Well, 37 feet, the rest bored, 3 inches diameter.

Water-level to 50 feet down.

Gault [? including some Chalk Marl]		166	174½ feet.
[Lower Greensand]	Brown sand	1	
	Running sand	6	
	Rock	1½	

8. Cottage opposite the Robin Hood. 9. Bishop's Charity Farm. 10. Hill's Charity Farm.

Communicated by H. TOMLISON, C.E.

	8.	9.	10.
Height above Ordnance Datum	55	167	171
Water-level below surface	37½	126	129
Depth of well in chalk	40	132	132

11. Laundry. About 375 yards N.N.E. from the Engine-house of the Cambridge Waterworks.

About 31¼ feet above Ordnance Datum.

Information from Mr. PRATT, on the spot, 1909.

A boring of 4 inches diameter to 120 feet, then of 3 inches.

Water rose to within 16 feet of the surface.

		Thickness. Feet.	Depth. Feet.
Soil		¾	¾
[Chalk Marl]	Clay	5	5¾
	Clunch	45	50¾
[Gault]	Blue clay	120	170¾
	Bear's muck [? clayey greensand]	? 2	172¾
[Lower Greensand]	Sand	about 8	180¾

W. W. GRAY, Engineer of the Cambridge Waterworks, noted in 1909 that when the Water Company is pumping with its compressor, the water-level is lowered 32 feet, to 48 feet down. Also that the Laundry Co. was about to put down an air-lift-pump, having had to resort to a surface-water-well.

Chesterton, *see* Cambridge.

Cheveley.

Ordnance Map 188, new ser. (Cambridgeshire 42, S.E.)
Geologic Map 51, S.E.

1. Stud Farm, Mr. Cooper's.

Made and communicated by Messrs. ISLER & Co.

Well, 20 feet (the rest bored).

Lined with 85 feet of tubes of 6 inches diameter, 12 feet down. Water level 162 feet down. Supply about 1,200 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[Boulder Clay]	Blue clay and chalk	42	42
	Blue clay and flints	5	47
	Blue clay and chalk	7	54
	Blue clay and flints	3	57
	Red rock [? boulder]	$\frac{1}{3}$	$57\frac{1}{3}$
	Blue clay, chalk and flints	$10\frac{2}{3}$	68
	Blue clay and flints	3	71
	Red clay and flints	4	75
[Upper Chalk]	Hard chalk and flints	20	95
	Soft dry chalk	10	105
	Soft chalk and flints	35	140
	Soft dry chalk and less flints ...	22	162
	Soft dry chalk	37	199
	Hard chalk and flints	51	250
	Very hard chalk and flints	6	256
	Hard chalk and flints	56	312

2. In the village.

Made and communicated by WARREN, of Bury.

Chalk, 150 feet.

3. ? For Cheveley and Wood Ditton. 1912.

Communicated by Messrs. SANDS and WALKER.

384·23 feet above Ordnance Datum.

Rest water-level 184 feet down.

A 14 days' pumping test yielded up to 1,800 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil and clay		5	5
[Drift]	Whitish-blue Boulder Clay, with flints and chalk	65	70
	Yellow clay, with flints and chalk ...	7	77
	Whitish-blue clay	2	79
	Yellow clay	23	102
Chalk		298	400

Chishall, Great.

Ordnance Map 205, new ser. (Cambridgeshire 62A and N.W.)
Geologic Map 47.

1. Trial-bore, 4 inches diameter, near the Hall. For Melbourn Rural District Council, 1900.

Made and communicated by H. G. FEATHERBY.

No water.

		Thickness. Ft. in.	Depth. Ft. in.
[Drift]	Top soil	1 0	1 0
	Yellow sandy clay	2 0	3 0
	Sandy gravel	2 0	5 0
	Yellow loam...	1 0	6 0
	Sandy clay with chalk-stones ...	2 0	8 0
	Brown clay	3 0	11 0
	Blue clay	12 7	23 7

Chishall, *cont.*

2. Another trial bore near the Hall, for the Melbourn Rural District Council, also made and communicated by H. G. Featherby, 1900.

		Thickness. Ft.	in.	Depth. Ft.	in.
[Drift]	Top soil	1	0	1	0
	Yellow clay	1	0	2	0
	Brown clay...	8	0	10	0
	Blue clay	6	8	16	8
	Sandy parting	?			

A well dug later on this spot proved the "sandy parting" to be very thin and the "blue clay" to extend down to more than 30 feet.

Comberton.

Geologic Map 187, new ser. (the village is in Ordnance Map 204, new ser.) Cambridgeshire 46, N.E.

Whitwell Farm, N.E. of the village.

Communicated by Mr. Flavell.

[Chalk Marl]	Soil and white clay	25	135 feet +.
[Gault]	Blue clay	110	
[Lower Greensand]	rocks and sand	—	

Conington.

Geologic Map 187, new ser. (Cambridgeshire 33 S.W.)

Prof. Seeley, "*Ann. Nat. Hist.*," ser. iii; vol. x. p. 103.

Blue clay	100	250 feet.
Hard rock (? St. Ives Rock)	5	
Blue clay, to rock yielding a small supply of *salt* water	145	

Coton.

Ordnance Map 188, new ser. (Cambridgeshire 39, S.E., 46 N.E.)
Geologic Map 51 S.W.

1. Communicated by Mr. Flavell.

[Chalk Marl]	Soil and white clay	11	131 feet+.
[Gault]	Blue clay	120	
[Lower Greensand]	Rocks and sand	—	

2. Wells at coprolite-works.

Communicated by N. W. Johnson.

Gault	120 to 130 feet.
[Lower Greensand] rock and sand	8 „ 12 „

Cottenham.

Ordnance Map 188, new ser. (Cambridgeshire 84.)
Geologic Map 51, N.W.

1. Landbeach Road (southern side), on western side of watercourse, about 1¾ miles south-eastward from the church.

Trial-boring for the water-supply of the village, 1885.

Communicated by Mr. Peed, of Cambridge.

Shaft about 5 feet.

The yield of water was small, and the quality bad.

	Thickness. Feet.	Depth. Feet.
Top soil	3	3
Solid Gault	20½	23½
[Lower] Greensand, with hard rock (specimen, calcareous sandstone), about 9 inches thick, 33½ feet down	18	41½
Blue [Kimeridge] Clay	38½	80

Cottenham, *cont.*

The thinness of the Lower Greensand is remarkable, and to it is probably owing the small quantity of water found.

2. Public Supply, S.W. of the Village, 1898.

Communicated by W. B. Ffolkes.

About 17 feet above Ordnance Datum. Shaft of 8 feet diameter.

Water-level 2½ feet down. (8 feet in 1908.)

[Gault?]	Loose clay	20	25 feet.
	Rock	3	
[Lower]	Greensand	2?	

According to the Water Works Directory, 1911, the population supplied was 2,550. According to the Local Government Board Return of 1915, p. 230, the New Cottenham Company supplies parts of the parishes of Cottenham and Rampton from a well 41 feet deep, 1¾ miles from the village (half way to Histon). The average daily supply is 15,000 gallons, and 75,000 more could be got. The supply is constant, and the water is very good and soft.

3. Communicated by Mr. Flavell.

Black earth	4	204 feet+.
Blue clay, mixed with rock	200	
Rock and sand	—	

T. Roberts says ("Jurassic Rocks of Cambridge," 1892, p. 47): "The greater part of the blue clay is of Ampthill Clay age, though its upper portion is probably Kimeridgian. The 'rock and sand' may be the Lower Calcareous Grit."

Ditton, *see* Fen Ditton and Wood Ditton.

Doddington.

Ordnance Map 172, new ser. (Cambridgeshire 15, S.E. 20, N.E.)
Geologic Map 65.

The Union, N.W. of the Church.
Blue clay. Rock-bed 6 feet thick at the base. 180 feet. C. Reid.

Dry Drayton.

Geologic Map 187, new ser. (Cambridgeshire 39 N.E., S.E.)

Scotland Farm, S.S.W. of the village.

Sunk 114 feet, bored 30 feet.
Water, 100 feet from surface.
Boulder Clay and Gault.
The wells in the lower part of this village are 50 feet deep, in the upper part by the rectory, 180 to 190 feet.

Dullingham.

Ordnance Map 188, new ser. (Cambridgeshire 49, N.W.)
Geologic Map 51, S.E.

Malting, near Railway Station. 1876.

Made and communicated by G. Ingold.

Water at 146 feet.

Soil		3	160 feet.
Chalk	Soft chalk, no flints	50	
	Hard chalk, no flints	107	

Duxford.

Ordnance Map 205, new ser. (Cambridgeshire 54, S.E., 59, N.E.)
Geologic Map 47.

1. Dr. W. ARMISTEAD. Reports to Linton Rural District Council for 1912–1914.

Wells in Chalk from 7 to 160 feet deep.

2. Aerodrome.

Made and communicated by Messrs. ISLER and Co., 1915.

Water-level 12 feet down, standing; 14 feet, pumping. At the depth of 150 feet it was 14 feet down, but rose 2 feet during the last 4 feet of boring.

Supply 6,714 gallons an hour for 6½ hours.

Mould		2	154 feet.
[Gravel] Ballast		2	
[Middle Chalk]	Grey chalk	25	
	Chalk and flints	125	

East Hunts. Water Co.

This Company supplies the Cambridgeshire villages of Bourn, Conington, Knapwell, Long Stowe, and Swavesey.

Elsworth.

Geologic Map 187, new ser. (Cambridgeshire 38, N.E., 39, N.W.)

T. ROBERTS, "Jurassic Rocks of the Neighbourhood of Cambridge," 1892, p. 20.

"A well was recently dug near the school . . . just above the outcrop of the Elsworth Rock, and in it two limestone beds were pierced."

Ely.

Ordnance Map 173, new ser. (Cambridgeshire 26 S.W.)
Geologic Map 51, N.W.

Market Street, Legge's Brewery.
From information on the spot, 1882.
Can get 3,500 gallons a day.

Sand, &c. [Lower Greensand]	15	20 feet.
Blue gault [Kimeridge Clay]	5	

Waterworks, *see* Isleham.

Stuntney Hamlet is also supplied. The total population supplied was 7,000 and the yearly supply 69,468,000 gallons, the daily consumption per head being 27·2 gallons for all purposes. Water Works Directory, 1911.

Eversden (? Great or Little).

Ordnance Map 204, new ser. (Cambridgeshire 46, S.W.. S.E.)
Geologic Map 51, S.W.

1. Coprolite Works.

Communicated by N. W. JOHNSON.

Gault	125 to 135	135 to 150 feet.
Lower Greensand, rock and sand ...	10 to 15	

2. The Quarry.

Water 64 feet from surface.
Chalk 72 feet.

Fen Ditton.

Ordnance Map 188, new ser. (Cambridgeshire 40, S.E.) Geologic Map 51, S.W.

1. Coprolite Works.

Communicated by N. W. JOHNSON.

	Feet.
[Chalk Marl] white clay, varies from	3 to 30
[Gault] blue clay	108 to 120
[Lower Greensand] rock and sand, varies from ...	9 to 12

2. Plough Inn.

	Feet.
Clunch	20
Gault	110
Rock and sand	10 or 20

3. Parish Pump, corner of cross-roads E. part of village.

4. Parish Pump N. end of village.

In the bore plenty of water could be got. Villagers said that there was no loss at any time. Made a few years ago.

No. 3, made a few years ago, yields very little water; but No. 4 plenty. Water is laid on here from the Cambridge Waterworks. W. W. GRAY, 1909.

Foulmire.

Ordnance Map 205, new ser. (Cambridgeshire, corner of sheets, 53, 54, 58, 59.) Geologic Map 47.

Aerodrome 1917.

Made and communicated by Messrs. ISLER & Co.

10 feet of 10 inch tube 2 feet down.

[Lower Chalk ?]	Chalk	135	170 feet.
	Grey chalk	·35	

Foxton.

Ordnance Map 205, new ser. (Cambridgeshire 53, S.E.) Geologic Map 51, S.W.

New Printing Works.

Made and communicated by Messrs. ISLER & Co.

20 feet of tubes 5 inches in diameter from 3 feet down and 250 feet of 4 inches diameter. Water-level 4½ feet down.

		Thickness. Feet.	Depth. Feet.
Soil		1	1
[Drift]	Chalk	1	2
	Gravel	2	4
	Sandy gravel	1½	5½
[Chalk]	Chalk	18	23½
	Clayey chalk	46	69½
Gault		164½	234
[Lower Greensand]	Loamy sand and pebbles [? phosphatic nodules].	15½	249½
	Loamy sand	29½	279
	Dark loamy sand ...	20	299

Fulbourn.

Ordnance Map 205, new ser. (Cambridgeshire 48, W. and 47, E.)
Geologic Map 51, S.W.

1. Cambridge Waterworks. Trial-boring (? not used for supply). Specimens every 5 feet in glazed case. Over 30 feet to water, September, 1909.

Communicated by W. W. Gray, Engineer to the Co.

		Thickness. Feet.	Depth. Feet.
[Chalk Marl ? all]	White chalk (5 to 45) ...	45	45
	Very pale grey chalk (or clay ?) the change well-marked (50 to 100) ...	55	100
[Gault, 135 feet]	Clay, darker grey, with bits of lighter grey [? carried down] (105, 110)	10	110
	Ditto, with round stone ..	5	115
	Ditto, rather darker downward (120–230) ...	115	230
	Specimen doubtful "This should be 5 feet of stone" inscribed on the space [? phosphates, &c., at base of Gault] ...	5	235
[Lower Greensand 65 feet] ...	Greenish-grey sand (240–275)	40	275
	Brownish sand. At 282 feet iron-sandstone	7	282
	Brownish-grey sand (287–297)	15	297
	Green-grey sand ...	3	300

No sign of Glauconite-grains in any specimen of the Chalk. The sands of the Lower Greensand are fine-grained, except that at 287, which is coarser.

According to Dr. Copeman's Report to the Local Government Board, 1906, the pumping well in the engine-house is connected at its lowermost point, 50 feet down, by a horizontal gallery, with the pilot-shaft, from which the water is got, and which is 70 feet deep.

The average amount pumped was 750,000 gallons a day, with the effect of lowering the water in the pilot-shaft about 7 feet; but the water is said to rise to the overflow (7½ feet below the top of the coping) in the pilot-shaft in 20 or 30 minutes from cessation of pumping. For the effect on other wells *see below* under 2.

According to the Report of Dr. Forbes and E. W. Harry, the bulk of the water enters the well about 15 and 35 feet above the surface of the Gault.

In a letter, to the Local Government Board, on 27th February 1914 Mr. Gray, gives the following water-levels, in a well in the Chalk 68 feet deep, the top 39 feet above Ordnance Datum. At rest 30·83 feet above Ordnance Datum, when pumping 21·83.

For an analysis of the water, *see* p. 122.

2. County Asylum.

Communicated by Dr. Bacon (Medical Superintendent).

Shaft throughout, water rises to 56 feet from surface.
Clunch 59½ feet.

Fulbourn, *cont.*

The following particulars are from Dr. COPEMAN'S Report to the Local Government Board, 1906. The well is under the engine house, about the centre of the block of buildings. It is of brickwork and at the base the chalk is deeply fissured. "Pumping usually goes on for twelve hours daily, and the average amount of water raised is 70,000 gallons . . . about 100 gallons per head . . The abstraction of this amount of water exerts practically no effect on the water level" (with one exception), and during 36 years "no change of the plane of saturation has been obvious beyond a difference of about one foot between wet or dry seasons."

A deepening (by 3 or 4 feet) "was necessitated by the practically complete emptying of the well, in 1890, at a time when in order to enable them to cement the bottom of their pumping well, the Waterworks Company were withdrawing no less than 3,000,000 gallons per diem; the water-level . . . rising again to the ordinary level as soon as the pumping operations at the Waterworks reverted to the normal. On this occasion also . . all 'drains,' ditches, and ordinary wells in the neighbourhood, and more especially in the village of Fulbourn . . . were more or less completely dried up." . . .

"Some of these ditches, which had become permanently dry, have been recently filled in."

For an analysis of the water, *see* p. 122.

3. Fulbourn Mill, W. of the village.

4. Fulbourn Lodge.

5. Fulbourn Valley Farm.

Communicated by H. TOMLISON, C.E.

	3. Feet.	4. Feet.	5. Feet.
Height above Ordnance Datum	110	158	100
Depth of well in chalk	76	117	56
Water-level, below surface	74	114	53

6. Mill House (over half a mile E.S.E. of the church).

W. W. GRAY tells me that two trial-bores were made to the depth of 20 feet, all in Chalk Marl; but no water was found. The level here is about 46 feet above Ordnance Datum, about the same as at the Shardelowes Springs, to the east, *see* p. 28.

Gamlingay.

Ordnance Map 204, new ser. (Cambridgeshire 45, S.W., 52, N.W.)
Geologic Map 52, S.E.

Castle Farm, S.E. of Railway Station.

Well, marked on MS. Geol. Survey Map. (Cambridgeshire 52, N.W.)

Gault	15	26 feet.
Lower Greensand	11	

Girton.

Ordnance Map 188, new ser. (Cambridgeshire 40, N.W., S.W.)
Geologic Map 51, S.W.

1. Inn near the Rectory.

Sunk 33 feet, the rest bored.

Gravelly soil	3	63 feet.
Blue clay [Gault]	50	
Clayey sand and greensand	9	
Rock, with water	1	

Girton, *cont.*

2. The College.

Well, 60 feet. Bored 56. Total 116. 3 borings.
There has been 17 feet of water in the well. 5 feet later. 45 feet down, 1894.

3. New School House. 1902.

Water 30 feet down, 1902. 45½ in February 1909.
Well 46 feet. Boring 25. Total 71.

Graveley.

Geologic Map 187, new ser. (Cambridgeshire 38, N.W.)

Rev. O. FISHER, *Proc. Cambr. Phil. Soc.*, Vol. xiii, pt. iv., pp. 181–183.

Well 94 feet, the rest bored.

	Thickness. Feet.	Depth. Feet.
Boulder Clay. Dark blue when wet, somewhat sandy, full of scratched pebbles of chalk and bits of flint. Red Chalk and Kimeridge shale not uncommon	50	50
Oxford Clay. Many shells of *Gryphœa dilatata*	252	302
Cornbrash. Dark stone, consisting chiefly of comminuted shells with a few oolitic grains ...	1½	303½
Clay, to hard rock	1	304½

A little water came into the bore-hole, but it was salt. The work was abandoned.

Great Abington *see* Abington.

Great Chishall *see* Chishall.

Great Wilbraham *see* Wilbraham.

Hardwick.

Whitwell Farm, given as in this parish in "The Geology of Cambridge," 1881, is in Comberton, which see.

Harlton.

Ordnance Map 204, new ser. (Cambridgeshire 46, S.E., 53, N.E.).
Geologic Map 51, S.W.

Coprolite works.

Communicated by N. W. JOHNSON.

Gault	125 to 135	feet.
Lower Greensand, rock and sand	10 to 15	

Harston.

Ordnance Map 205, new ser. (Cambridgeshire 53. E. 54, W.)
Geologic Map, 51, S.W.

1. Corner of road to Newton.
Small bore into Lower Greensand, overflowing, September 1909.

2. Adjoining Dr. Young's house.

Bore into Lower Greensand, cleaned in 1905. A fairly large quantity coming from a 1½ inch-pipe, the water nearly at surface-level. W. W. GRAY, 1909.

Harston, *cont.*

3. The Chequers, public house, near 4th milestone (from Cambridge). Boring into Lower Greensand. Water just dribbling from upright pipe. W. W. Gray, 1909.

4. Pemberton Arms. In road opposite I saw (1910) a boring, from which water overflows, at the rate of 4,000 gallons a day. But it has ceased to flow at times.

5. At the eastern side of the road, about a sixth of a mile E.N.E., another bore overflowed at the rate of about 2,000 gallons a day.

Haslingfield.

Ordnance Maps 205, 204, new ser. (Cambridgeshire 46, S.E., 53, N.E.), Geologic Map 51 S.W.

1. Cantalupe Farm.

Made and communicated by C. Lack, of Cottenham.

Well 25 feet, boring 118, total 143 (into Lower Greensand).

Water 2 feet down, 1902.

2. Carpenters' Arms, or Daintrees Inn.

Sunk 33 feet, the rest bored.

Gault, Blue clay, sandy at bottom	153	173 feet.
Lower Greensand, sand, &c.	20	

Pump now covered over. A long way back from the house; perhaps an old Coprolite-boring,

3. Coprolite Works near Cantalupe Farm.

Obtained from the Foreman.

Clunch [Chalk Marl]	20	150 feet.
Blue Clay to rock [Gault]	130	

4. Coprolite Works.

Communicated by N. W. Johnson.

Gault	135 to 145 feet.
Lower Greensand, rock and sands ...	9 „ 18 „

5. Near the Church.

Communicated by Mr. Pond.

Clunch with coprolites at bottom	14	157 feet.
[Gault] clay with coprolites (and *Ammonites interruptus*) at bottom	140	
[Lower Greensand] rock and green sand ...	3	

6. Riverside (? or River) Farm.

Information from W. W. Gray. 1909.

Boring said to have been made over 100 years ago. Water rises 8 feet above ground, with a small dribble into a tank. Now hardly enough water for domestic supply. In 1906 the bore was cleaned out and a fair supply got. Now water from the river is used for farm-purposes. Water from an old coprolite-boring, near the river, overflows and enters the river.

According to C. Lack a boring at River Farm (? same as above) is 148 feet deep, and water rose to 10 feet above ground in 1904.

7. Spring Hall Farm. North of the village.

A boring (? 160 feet deep) used to overflow into a pond close by. In April 1910 the water was about 6 feet down.

Hatley St. George.

Ordnance Map 204, new ser. (Cambridgeshire 52, N.E.) Geologic Map 52, S.E.

Communicated by H. TOMLISON, C.E.

Sunk 170 feet, the rest bored.
Water rose within 140 feet of the surface

		Thickness. feet.	Depth. feet.
Drift	Clay with chalk stones [Boulder Clay]	120	120
	Gravel (chalk, flints and pebbles) ...	28	148
Gault (clean blue clay)		22	170
Lower Greensand		30	200

Heydon.

Ordnance Map 205, new ser. (Cambridgeshire 59, S.W.) Geologic Map 47.

Near Heydon Grange.
About 160 feet above Ordnance Datum.
Water-level about 68 feet down.
Yield sufficient for the Farm.
80 feet deep apparently all chalk to within a foot or so of surface.
For analysis of the water *see* p. 123.

Hildersham.

Ordnance Map 205, new ser. (Cambridgeshire 55, S.W.) Geologic Map 51, S.W.

Dr. W. ARMISTEAD. Reports to the Linton Rural District Council for 1912 to 1914.
Wells in Chalk and Gravel, from 7 to 28 feet deep.

Hinxton.

Ordnance Map 205, new ser. (Cambridgeshire 59, N.E.) Geologic Map 47.

Dr. W. ARMISTEAD. Reports to Linton Rural District Council for 1912–1914.
Public pump, with tube-well bored into the Chalk to depth of 148 feet. Water rising to 27 feet from the surface.
Private wells dug in Chalk to depths of 11 to 70 feet.

Histon.

Ordnance Map 188, new ser. (Cambridgeshire 40, N.W.) Geologic Map 51, S.W.

Fruit Mills, by the Railway Station. (Chivers.)
Well 60 feet, the rest bored. Water 40 feet down in 1908. Yield 63,000 gallons a day.

[Valley Drift] gravelly loam	5	70 feet.
[Gault] Blue clay	60	
[Lower Greensand] rock and sand	5	

According to W. W. GRAY (1909) there are two wells, and in each three bores. The new well is of 15 feet diameter, the bores being of 6 inches, with three pumps capable of raising 30,000 gallons an hour. In 1908 this well was pumped dry each day during the summer.
For an analysis of the water, *see* p. 123.

Horningsea.

Ordnance Map 188, new ser. (Cambridgeshire 40, N.E.)
Geologic Map 51, S.W.

1. Near Eye Hall Farm. (High Hall of the old Map.) N.N.E. of the village.

Communicated by R. Piggot (Guilden Morden).

Soil and White Clay [Chalk Marl]	15	145 feet.
Blue clay [Gault]	120	
Rock and sand [Lower Greensand]	10	

In 1909, the bailiff said that there was plenty of water in the boring.

2. St. John's College Farm.
Well 46 feet. Boring 86 (made in 1908.) Total 132.
Water-level 27 feet down, 1908.

Horseheath.

Ordnance Map 205, new ser. (Cambridgeshire 56, S.W.) Geologic Maps 47, 51, S.E.

Dr. W. Armistead. Reports to the Linton Rural District Council for 1912–1914.

A private well in the village is dug 115 feet into the Chalk.

Of four public pumps three are supplied by filtered pond-water, the other from a spring.

Ickleton.

Ordnance Map 205, new ser. (Cambridgeshire 59, N.E.) Geologic Map 47.

Dr. W. Armistead. Reports to the Linton Rural District Council for 1912–1914.

Public pump. Well in Chalk.

Other wells, in Chalk or Gravel, from 7 to 195 feet deep.

A private well bored 232 feet into the Chalk and lined for 101 feet with iron tubes. Water rose to 4 feet from the surface.

Impington.

Ordnance Map 188, new ser. (Cambridgeshire 40, W.) Geologic Map 51, S.W.

Impington Park.

Well 35 feet, boring 60, total 95.
Water about 25 feet down, in 1899,

But there are said to be 8 bores at the Hall (same place) all dry.

Isleham.

Ordnance Map 188, new ser. (Cambridgeshire 31, S.W.) Geologic Map 51, N.E.

Ely Waterworks, southward of the village.

Communicated by Messrs. Easton and Ffolkes and by G. Hook of Isleham.

24 feet above Ordnance Datum.

Shaft 27½ feet, the rest a bore of 6 inches diameter.

Isleham, *cont.*

Water-level about 17 feet down. Yield, when pumped down to 22 feet, about 450 gallons a minute.

		Thickness. Feet.	Depth. Feet.
Soil		about 1	1
[Chalk Marl]	Chalk	52½	53½
	Chalk Marl, with very thin coprolite-bed at the bottom ...	18	71½
[Gault] Clay		6	77½

For an analysis of the water, *see* p. 124.

According to the Local Government Board Return of 1915, p. 50, the average daily quantity of water available is 178,750 gallons, the daily average supply being 148,386.

According to a later account from Dr. ARMISTEAD, there is a well of 30 feet; then a boring of 30 inches diameter, 18 feet; then one of 16 inches for 26 feet, a total depth of 74 feet.

Kingston.

Ordnance Map 204, new ser. (Cambridgeshire 46, N.W. and S.W.)
Geologic Map 51, S.W.

Parish well.

Sunk 89 feet, the rest bored.

Water within 65 feet of the surface.

Gault (and Lower Greensand?) 189 feet.

Linton.

Ordnance Map 205, new ser. (Cambridgeshire 55, S., 60, N.)
Geologic Map 47.

1. Police Station, 1894. 2. Vicarage, 1896.

Made and communicated by G. INGOLD.

1. Old well 12 feet, the rest bored. Water-level, 8 feet down.

2. Boring. Water 15 feet down, good supply.

	1.		2.
Gravel	12	120 feet.	9
Chalk	108		111

3. Public Well, in the centre of the town, 1889, 135 feet above Ordnance Datum.

Water-level 12 feet down.

4. At Mr. Ficklin's, near the river; water-level 9½ feet down.

Made and communicated by G. INGOLD.

	3.	4.
[Drift] Gravel	17	12
[Drift] Brown clay	3	—
Chalk	100	110
	120	122

Linton, *cont.*

According to Dr. W. ARMISTEAD'S Reports to the Rural District Council for 1912–1914, there are three public pumps, supplied by tube-wells bored into Chalk to a depth of 120 feet and lined with 60 feet of iron tubes. Other wells vary in depth from 10 to 146 feet.

For an analysis of Linton waters, *see* pp. 124, 125.

Linton Rural District.

Ordnance Map 205, new ser. Geologic Maps 47, 51, S.W. and S.E.

Dr. W. ARMISTEAD, the Medical Officer of Health, has given a series of returns relating to the water-supply of the various villages in his Annual Reports, and it is convenient to give some of these for the whole district, instead of separating them.

His first tabular statement is on the last page of the Report for 1900 (Fol. 1901). The subject is again referred to on p. 3 of the Report for the following year.

The following tables are taken from the Reports for 1903 and 1905, in which the special particulars are given the most fully.

The subject is also noticed in the 33rd, 34th, 35th and 36th Reports, also in Fol. form.

The 39th, 40th and 41st Reports, for 1912–1914, are in 8vo form, and the notes given in them are used under the places mentioned.

30th Report for 1903, Fol. 1904, pp. 2, 3. The figures stand for feet.

	Well-mouth above Ordnance Datum.	Water-level above Ordnance Datum.
Parishes on Boulder Clay.		
Carlton	338	—
Weston Colville	325	240
West Wickham	340	223
Horseheath	323	223
West Wratting	353	207
Balsham	366	207
Castle Camps	405	—
Shudy Camps	300	181
Parishes on the Bourn and Granta.		
Bartlow	162	157
Linton	156	121
Hildersham	109	94
Great Abington	105	88
Little Abington	112	83
Babraham	87	72
Babraham Cambridge Road	87	62
Parishes in the Cam Valley.		
Ickleton	111	105
Hinxton	122	96
Duxford	95	86
Pampisford	94	76
Whittlesford	82	72
Sawston	82	70
Pampisford Springs	—	79
Sawston Springs	—	54

Linton Rural District, *cont.*

Particulars of Chalk Wells. From the 32nd Rep. for 1905, Fol. 1906, p. 2.

The figures stand for feet.

Place.	Level of Curb above Ord. Datum.	Depth to Water.	Depth to Bottom	Level of Water above Ord. Datum.	Chalk from surface.	Remarks.
Abington, Great ...	103	15	20	88	5	Dug.
Abington, Little ...	112	30	36	82	5	,,
Babraham	88	26	32	62	—	,,
Balsham, Public Well	366	159	165	207	45	,, Deepened 5½ ft. in 1901.
Bartlow, Private Well	102	5	11	157	near	,,
Duxford	95	9	13	86	near	,,
Hildersham, School Well	124	20	22	104	11	,,
Hinxton	122	26	148	96	22	Bored in 1903.
Horseheath, Batson Arms	323	100	119	223	—	Dug.
Ickleton	111	6	7	105	near	,,
Linton, Police Station	About 130	8	120	About 122	12	Bored in 1894.
Pampisford	87	13	120	74	3	,, ,, 1883.
Sawston, Public Well near Church ...	81	15	120	66	8	,, ,, 1893.
Shudy Camps, Private Well in village ...	300	120	134	180	37	Dug.
West Wickham, Public Well	340	117	128	223	53	,,
Weston Colville, Public Well ...	325	86	104	239	—	,,
West Wratting, Public Well	353	148	154	205	34	,,
Whittlesford, Public Well	81	9	85	72	near	Bored in 1886.

Lolworth.

Geologic Map 187, new ser. (Cambridgeshire 29, N.E.)

Cottage, a mile east of village.

Sunk 35 feet, the rest bored.

No supply, but bore fills in at the bottom when left for a few hours.

Dark [Kimeridge] clay, with bed of rock 30 feet from surface, and at every few feet below, 135 feet.

Little Abington, *see* Abington.

Long Stanton, All Saints.

Geologic Map 187, new ser. (Cambridgeshire 33, S.E.)

According to the Local Government Board Return of 1915, p. 36, part of the parish is supplied from a well in Gravel. The supply is ample and the water is good, but fairly hard.

Long Stowe.

Ordnance Map 204, new ser. (Cambridgeshire 45, N.E., S.E.)
Geologic Map 52, S.E.

A letter from HAROLD WARREN (1899) says that he had pieces of wood in Lower Greensand rock, from about 100 feet down, in a well.

Madingley.

Geologic Map 187, new ser. and 51, S.W. (Cambridgeshire 39, S.E.)

1. Communicated by Mr. FLAVELL.

Soil	3	157 feet.
[Chalk Marl] white clay, with coprolites at bottom	14	
[Gault and Lower Greensand] blue clay, rocks and sand	140	

2. Madingley Road.

Communicated by Mr. FLAVELL.

Soil and Gravel	7	133 feet.
[Chalk Marl] white clay, with coprolites at bottom	6	
[Gault] blue clay	120	
[Lower Greensand] rocks and sand	—	

According to the Local Government Board Return of 1915, p. 247, COL. HARDING supplies part of the parish from a well 240 feet deep, in Greensand. The daily average supply was 1,750 gallons, the supply being constant. The water is fit for drinking, but hard.

March.

Ordnance Map 159, new ser. (Cambridgeshire 12 S.W., 16 N.W.).
Geologic Map 65.

Railway Station 1883.

Boring, communicated by J. S. WINBOLT, who also showed me specimens (described in brackets). Fossils determined by G. SHARMAN.

	Thickness. Feet.	Depth. Feet.
Made ground (clay with stones, etc.)	11	11
Ballast (shelly gravel)	1	12
[Kimeridge] Clay (fragments of *Ammonites biplex*? and of *A. cordatus*? at 15 feet), septaria at 65 to 66	58	70
[Oxford] Clay, light-grey rather darker in parts, with septaria at or near top, at 84 to 85½, at 93½ to 95, at 143 to 144½, at 148½ to 150, at 155 to 157, at 167½ to 172, at 174½ to 176. *Gryphæa dilata* at 70 to 76, at 250 to 265 and at 274. *Avicula inæquivalvis* at about 128. Some stone, with bits of shell, between 145 and 160. Piece of wood at 249	214	284

There is some doubt as to the determination of the Ammonites, and unfortunately the specimens have not been kept. *A. biplex* is an Upper Kimeridge species, whilst *A. cordatus* is a Corallian one, though it occurs rarely in the Kimeridge Clay of Yorkshire, associated with *A. biplex*.

The Public Supply comes from the Wisbech Water Co. and is taken from Chalk-springs at Marham, in Norfolk. *See* Memoir on the Water Supply of Norfolk.

Melbourn.

Ordnance Map 204, new ser. (Cambridgeshire 58, N.E.) Geologic Map 47.

1. Heath Farm. For public supply (Meldreth and Melbourn).

Information from W. W. GRAY, Engineer of Cambridge Waterworks, 1909.

Old Well in Chalk, about 130 feet deep. Pump 100 feet down.

Proposed to sink a well in N.E. corner of orchard, E. of the farm. Not done?.

2. Police Station in the middle of the village, just behind Inn. 1894.

Made and communicated by G. INGOLD.

A boring, tubed for 41 feet.

Water-level 14½ feet down. Yield, 5 gallons a minute.

		Thickness. Feet.	Depth. Feet.
Soil		2	2
[Lower Chalk]	Brown, sandy chalk, with thin layers of clunch	12	14
	Hard grey chalk [?Totternhoe Stone]	15	29
	Hard clunch	1	30
	Light-brown chalk, with layers of clunch, changing gradually to the next below	15	45
	Slate-coloured chalk marl ...	38	83

For an analysis of Melbourn water, *see* p. 126.

Meldreth.

Ordnance Map 204, new ser. (Cambridgeshire 53, S.E.) Geologic Map 51, S.W.

1. Cement Works. On N. side of road about half way to Whaddon?.

Well 25 feet, Boring 200. Total 225.

Water from the Chalk pumped to waste. Continuous pumping said to lower the water in the shallow well at Elbourne Farm, about 700 yards E.S.E.

Water from bore, into Lower Greensand, used for boiler.

When not used this water overflows.

2. By the Church.

Water overflows.

Chalk and Gault, said to be 300 feet.

3. Railway Station.

Communicated by F. J. CARVER (Whaddon).

Water overflows.

[Chalk Marl] White clay, to coprolites ...	60	305 feet.
[Gault] Blue clay	240	
[Lower Greensand] Rock	about 5	

4. About a mile N.W. of the Railway Station.

Communicated by F. J. CARVER.

[Chalk Marl] white clay	30	248 feet.
Gault	210	
[Lower Greensand] rock	8	

Meldreth, *cont.*

5. Secondary School. At the southern part of the village, N. of Railway station.

Water rose to the surface.

70 feet of 6 inch boring.

Gault	165	183½ feet.
Loam	3½	
Sand	15	

6. A boring at the brewery, at the northern part of the village, is said to be 210 feet deep, and the water overflowed.

7. I saw the water overflowing from a deep bore at an angle in the roadside about a sixth of a mile S.S.W. from the brewery.

8. At the roadside at Chiswick End, nearly ¼ mile N.W. of the Railway Station a deep bore overflowed.

9. ? In Meldreth.

Cam Blue Lias Portland Cement Co.

Adjoining G.N. Railway, E. of village [?Church]. A 4 inch bore into the Lower Greensand. Depth 240 feet.

Chalk water, in pits, used for steam-purposes. Lower Greensand water not used.

Milton.

Ordnance Map 188, new ser. (Cambridgeshire 40.) Geologic Map 51, S.W.

Mr. Carlton's Nursery. 1904.

Well 27 feet; boring 68, total 95.

Water-level, 12 feet down, 1904.

In another well, made in 1907, the water-level was 20 feet down. On 8 February 1909 it was 17 feet down. But it is said that in the summer of 1908 the well dried frequently, and on 6 February 1909 it could be pumped for only 2 hours.

Water from Lower Greensand.

Newmarket.

Ordnance Map 188, new ser. (Cambridgeshire 12, N.W. and S.W.) Geologic Map 51, S.E.

In 1850 G. T. Clark, reporting to the General Board of Health, said "The chalk yields a good supply of water at a depth of about 40 feet, and the town is on the whole fairly provided with wells." . . .

"There are several pumps in the town, the water of which is for the most part good and plentiful. At the railway station is a well 40 feet deep, terminating in an 18-inch bore of 470 feet. The water rises to within 35 feet of the surface." A tank of 18,000 gallons is said to be filled in five hours. It was suggested that this supply should be extended, for the town.

1. Lower Hare Park.

Made and communicated by Messrs. Isler & Co.

Lined with 360½ feet of tubes 6 inches diameter from 10 feet down. 32 feet of 5 inches diameter (perforated) 355 feet down.

Water-level 72 feet down.

		Thickness. Feet.	Depth. Feet.
Chalk	Dug Well. Chalk ...	—	4
	Chalk	116	120
[Gault ? and Chalk Marl]	Blue gault	143	263
	Blue clay	99	362
[Lower Greensand]	Green sand	15	377
	Green sand stone ...	10	387

Newmarket, *cont.*

Another account, from Mr. E. De la Rue (1899) differs, as follows:—

	Thickness. Feet.	Depth. Feet.
Chalk	130	130
Marl	138	268
Blue gault	99	367
Crust over green sand	3	370
Green sand	7	377
Clay	1	378

2. Moulton Paddocks. 1883.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 40 feet down. Yield 18 gallons a minute.

	Thickness. Feet.	Depth. Feet.
Dug well (old, the rest bored)	—	47
Chalk	15	62
Stone chalk	24	86
Hard grey chalk	10	96
Hard chalk	54	150

3. Sefton Lodge.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 58 feet down, in December 1883.

	Thickness. Feet.	Depth. Feet.
Dug well (old, the rest bored)	—	77
Chalk	35	112
Chalk stone and sticky marl	12	124
Chalk	53	177

4. Waterworks, about a mile south of Exning Church. 1883.

Communicated by Messrs. Easton & Ffolkes.

Shaft 20 feet 4½ inches, with gallery 3½ feet high, at the bottom. Two bore-holes, 12 inches in diameter, of 29 feet 7½ inches, or a total of 50 feet, all in chalk, except for about 1½ feet of soil at top.

The following addition communicated by Messrs. Isler & Co.

Made ground		3	
[Chalk]	Dry chalk	20	90 feet.
	Chalk	45	
	Clunch	22	

The *Water Works Directory*, 1911, gives the total population supplied as 12,000; the district supplied including Exning (in Suffolk); the well as 103 feet deep; the yearly supply as 125,000,000 gallons, the maximum day's supply being 550,000.

According to the Local Government Board Return of 1915, p. 205, the supply is extended to Burwell, Cheveley and Wood Ditton; the average daily quantity of water got was 268,493 gallons, and a further 400,000 could be got, but the daily average supply is given as 214,315. Supply constant. The water is of extreme purity.

For an analysis of the water *see* p. 125.

Orwell.

Ordnance Map 204, new ser. (Cambridgeshire 58, N.W. and N.E., Geologic Map 51, S.W.

Coprolite-works, S.E. of the village.

Water 20 feet down.

Clunch and Gault (? to Lower Greensand), 180 feet.

Over.

Geologic Map 187, new ser. (Cambridgeshire 33, N.E.).

1. Communicated by Mr. FLAVELL. No water.

Black earth and gravel	15	215 feet.
Blue clay, with chalk-stone and black rocks ...	200	

T. ROBERTS says ("Jurassic Rocks of Cambridge," 1892, p. 48) that the blue clay is Ampthill Clay, and not Oxford Clay, as originally classed.

2. E. end of village.

From A. C. G. CAMERON'S notes.

Well 50 feet, bored 80. No water.

All clay, with a little stone near the bottom.

Pampisford.

Ordnance Map 205, new ser. (Cambridgeshire 54, S.E.).
Geologic Map 51, S.W.

1. Centre of village, near the Chequers Inn.

Made and communicated by G. INGOLD.

Bored throughout. Water-level 14 feet down.

		Thickness. Feet.	Depth. Feet.
[Middle and Lower Chalk]	Loose chalk	17	17
	Hard rocky chalk	36	53
	Very hard sandy chalk ...	2	55
	Whitey-brown chalk, with nodules of iron-pyrites at a depth of 110	68	123

2. Near Mr. Hamond's cottages. E. of the church.

Sunk and communicated by G. INGOLD.

Surface water-level about 5½ feet down; lower water-level, about 5⅔ feet.

		Thickness. Feet.	Depth. Feet.
Made earth		4	4
[Middle and Lower Chalk	Loose chalk	11	15
	Hard white chalk	27	42
	Hard brown chalk	2	44
	Hard white chalk	2	46
	Soft whitey-brown chalk, with nodules of iron-pyrites at a depth of 105 feet	79	125

3. Corner of Parish Field, near the Brewery.

Made and communicated by G. INGOLD.

Bored throughout.

Surface water-level, 5 feet 4 inches down; lower water-level, 5 feet 10 inches down.

		Thickness. Feet.	Depth. Feet.
[Middle and Lower Chalk]	Loose chalk	15	15
	Whitey-brown chalk, the bottom 7 feet hard ...	25	40
	Hard chalk, top third yellow, the rest white	6	46
	Softer chalk	37	83
	Hard white chalk	7	90
	Softer white chalk	5	95
	Chalk with yellow veins ...	2	97
	Whitey-brown chalk, with 18 inches of brown chalk, 6 feet down	28	125

Pampisford, *cont.*

4. Near the Vicarage.

Sunk and communicated by G. Ingold.

Surface water-level, 11½ feet down; lower water-level, 12¼ feet.

		Thickness. Feet.	Depth. Feet.
Mould		2	2
[Middle and Lower Chalk]	Hard white chalk	44	46
	Soft chalk	½	46½
	Hard chalk	9½	56
	Softer whitey-brown chalk, with nodules of iron-pyrites at a depth of 104 feet ...	69	125

5. Near the White Horse Inn. 1885.

80 feet above Ordnance Datum.

Made and communicated by G. Ingold.

Water rose to within 6 feet of the surface. According to later information this is a boring of four inches diameter, lined to the depth of 60 feet, and the rest-level of the water is 10 feet down.

		Thickness. Feet.	Depth. Feet.
Chalky gravel		7	7
[? Middle Chalk]	Clunch	8	15
	Yellow chalk	2	17
	Clunch	3	20
[Lower Chalk]	Soft white chalk, gradually getting tougher	95	115
	Brown sandy chalk [? Totternhoe Stone]	5	120
	Brown chalk, without sand [Chalk Marl]	5	125

For an analysis of the water *see* p. 126.

According to Dr. W. Armistead's Reports to the Linton Rural District Council for 1912–1914, five public pumps are supplied by tube-wells (? Nos. 1–5, above) bored into Chalk to a depth of 120 feet and lined with 60 feet of iron tubes.

6. Mr. C. Scruby's Brewery.

Sunk and communicated by G. Ingold.

Water-level 6 feet down, sustained pumping of from 40 to 50 gallons a minute. [Supply probably derived from the Totternhoe Stone].

		Thickness. Feet.	Depth. Feet.
Garden Mould		3	3
[Middle and Lower Chalk]	Soft white chalk	7	10
	Hard white chalk	16	26
	Hard white chalk with soft layers	5	31
	Hard chalk	13	44
	Soft grey chalk, with hard piece of chalk at bottom ...	69	113
	Very soft chalk	5	118
	Soft chalk, with hard piece at bottom	1	119
	Soft chalk	6½	125½

Pampisford, *cont.*

7. The Vicarage.

Made and communicated by G. INGOLD.

Water-level 14 feet down.

		Thickness. Feet.	Depth. Feet.
Made ground		2	2
[Middle and Lower Chalk]	Hard white chalk	43	45
	Light-brown clunch	15	60
	Softer brown chalk	107	167
	Hard clunch	3	170
	Light-brown chalk	6	176
	Blue marly chalk	4	180
	Brown chalk	10	190

Papworth Everard.

Geologic Map 187, new ser. (Cambridgeshire 38, N.E.).

T. ROBERTS, "Jurassic Rocks of Cambridge," 1892, p. 41.

Rock met with at a depth of 7 feet, but not pierced.

Sawston.

Ordnance Map 205, new ser. (Cambridgeshire 54, N.E. and S.E.).
Geologic Map 51, S.W.

1. Borough Mills.

The left column of figures is from particulars and specimens preserved at the Mills. The right column was communicated by G. INGOLD.

The water comes in from upper part of the Lower Greensand, and rises to 14 feet below the surface, at about 15 gallons a minute. The water is impregnated with salt.

	Thickness. Feet.	Feet.
Made ground	—	12
Chalk, at 47 feet a bed of flints with much water	145	150
Gault	167	150
Lower Greensand	65	65
? To Kimeridge Clay	—	377

2. Mr. Evans' Cottages. 1885.

Bored and communicated by G. INGOLD.

		Thickness. Feet.	Depth. Feet.
Mould		2	2
[Drift]	Gravel	5	7
	Sand	2	9
[? Middle and Lower Chalk]	Hard yellow chalk	11	20
	Softer white chalk	20	40
	Grey chalk	70	110

3. Cottages near the Langford Arch Works.

Made and communicated by G. INGOLD.

Bored throughout. Water-level, 3 feet down.

		Thickness. Feet.	Depth. Feet.
Mould		2	2
Sandy gravel		6	8
White clay		2	10
[Lower Chalk]	Chalk	10	20
	Loose sandy chalk	4	24
	Chalk	12	36
	Very hard chalk	14	50
	Whitey-brown chalk, with 2 feet hard, 42 feet down	70	120

Sawston, *cont.*

4. Woolpack Inn, communicated by Mr. HILLS and by Mr. CRAWFORD. Plenty of good water. Stood 37 feet down.

		Thickness. Feet.	Depth. Feet.
[Middle and Lower] Chalk		173	173
Gault		192	365
[Lower] Greensand		53	418
[? Kimeridge Clay]	Rock	3	421
	Clay	1	422
	Rock	1	423
	White marl	5	428
	Dark sand, with round stones	5	433

The thickness of the Gault seems excessive.

In the Memoir on Parts of Cambridgeshire and of Suffolk, 1891, p. 111, this is given, though with doubt, as in Cambridge.

5. Cottages a mile N.W. of the church.

Bored and communicated by Messrs. LE GRAND and SUTCLIFF.

Lined for 27 feet down.
Water-level 9 feet down.
All in [Lower] Chalk.
For an analysis of the water, *see* p. 127.

According to Dr. W. ARMISTEAD's Reports to the Linton Rural District Council for 1912–1914 there are seven public pumps, supplied by tube-wells bored to a depth of 120 feet into chalk and lined with 60 feet of iron tubes.

Shelford (? Great or Little.)

Ordnance Map 205, new ser. (Cambridgeshire 54, N.W.) Geologic Map 51, S.W.

1. Carlton Lodge.

Made and communicated by G. INGOLD.

Bored throughout.

		Thickness. Feet.	Depth. Feet.
Made ground		2	2
Gravel	Sandy gravel	3	5
	Coarse gravel with water	1	6
	Chalky gravel	3	9
Chalk	Soft whitey-brown chalk, the bottom foot with yellow veins	10	19
	Whitey-brown chalk	7	26
	Slate-coloured chalk marl. Small white chalk stones at 70 feet deep	57½	83½
	Darker chalk marl, sandy, with coprolites	¾	84¼
Gault.	Blue clay	15¾	100

2. Heath Farm.

156 feet above Ordnance Datum.

Communicated by H. TOMLISON.

Water stands at 96 feet from surface.
Chalk 102 feet.

Shelford, *cont.*

3. Lime-kilns, by Little Hill Inn.
119 feet above Ordnance Datum.
Communicated by H. Tomlison.
Water stands 71 feet from surface. Chalk, 75 feet

4. Mills by Railway Station.

		Thickness. Feet.	Depth. Feet.
Coarse gravel		10	10
[Chalk] Clunch, with coprolite-bed at bottom ...		90	100
[Gault] Blue clay		170	270
[Gault] Soft bluish earth ("bear's muck") ...		2	272
[Lower Greensand] Brown quick-sand ...		6	278
[Lower Greensand] Dark grey ironstone rock		2	280

5. Red Cross, opposite the toll-house.
69 feet above Ordnance Datum.
Communicated by H. Tomlison.
Water stands 25½ feet from surface.
Chalk, 32 feet.

6. For Mr. A. Sedgwick. About a mile E. of Railway Station, 1891.
Made and communicated by G. Ingold.
Shaft 93 feet deep, the rest bored. Water-level 91 feet down.

Made earth	3		
[Lower Chalk] Loose chalk with layers of clunch ...	77	123 feet.	
[Lower Chalk] Solid hard clunch...	43		

7. Another section (? a version of one of the above).

Upper formation [Drift] and chalk	300	
Gault	50	370 feet.
Rock	20	

8. Rectory Farm.
Made and communicated by Messrs. Le Grand and Sutcliff.
Bore-pipe to 40 feet down.
Rest-level of water 2½ feet down.

Soil	8	
[Lower] Chalk	92	100 feet.

Shepreth.

Ordnance Map 204, new ser. (Cambridgeshire 53, S.E.) Geologic Map 51, S.W.

1. Rhee Valley Cement Works, 1897.
From particulars given by Mr. Gildea and from specimens in the possession of G. Ingold, who made the boring.
A. J. Jukes-Browne. Cretaceous Rocks of Britain, Vol. i, p. 289, (1900) with some MS. notes.
Boring of six inches diameter, yielding an abundant supply of water (at 25 feet down: about 3,000 gallons an hour. G. Ingold).

		Thickness. Feet.	Depth. Feet.
Soil		5	5
Sand, gravel and patches of marl			
Chalk Marl	Yellow marl (specimen at 14 feet whitish Chalk Marl)	10	15
	Bluish marl (specimens at 24, 30 and 51 feet, grey, the last with quartz grains, but little glauconite	36	51
	Coprolite-bed (specimen marl), with much glauconite, and black phosphatic nodules)	1	52

Shepreth, *cont.*

		Thickness. Feet.	Depth. Feet.
Gault, 155½ feet	Blue gault. Samples of light-grey clay from 53, 77 and 127 feet ...	98	150
	Hard band with coprolites. Sample of small buff-coloured phosphatic nodules from 155 feet	5	155
	Blue gault. Samples of light-grey clay (with small phosphatic nodules at 160 and 173 feet) and 175 feet. Samples of darker grey clay streaked with light-grey, from 189, 193 and 200 feet (the last with fragments of black phosphate and small *Belemnites*)	45	200
	Hard band, with large lumps of blackish phosphatic nodules ...	1½	201½
	Very hard clay	6	207½
Lower Greensand 33½ feet	Hard green sandy clay. Sample from 208 feet coarse, brownish pebbly sand, with some clay. (Sample from 210 feet, as above with piece of sandy phosphatic nodule)	3½	211
	Rock. Brown sand with a piece of sandy phosphatic nodule ...	½	211½
	Compact dark greensand. Sample of rather coarse yellow sand from 220 feet	22½	234
	Darker loose greensand. Sample of greenish-grey sand from 235 feet	2	236
	Dark clayey band, with nodules of pyrites. Sample from 23 feet dark grey sand mixed with a little clay, with many scales of mica	3	239
	Loose sand	2	241

2. House recently built by Mr. HART, by whom information was given, in 1909.

A boring of 4 inches diameter.

Soil	5	230 feet.
Chalk	50	
Gault	170	
[Lower Greensand]. Sand	5	

Shudy Camps.

Ordnance Map 205, new ser. (Cambridgeshire 61, N.W.) Geologic Map 47.

Made and communicated by G. INGOLD.

Well 103 feet, the rest bored.

[Boulder Clay]	Loam and Boulder Clay ...	25	255 feet.
	Chalk, and clay	3	
[Upper] Chalk, with flints		227	

According to Dr. W. ARMISTEAD's Report to the Linton Rural District Council for 1914 there are (other) wells dug through Boulder Clay into Chalk, from 134 feet deep. At Mill Green a public pump is supplied by filtered pond-water.

Soham.

Ordnance Maps 188, 173, new ser. (Cambridgeshire 30, S.E.)
Geologic Maps 51, N.W., N.E

1. Board Schools. From S. B. J. Skertchly's Notes.

[Chalk Marl]	Clunch, some very hard ...	16¾	20¼ feet.
	Coprolite-bed, 3 inches ...		
Hard blue Gault		4	

Bored deeper, but how deep could not be learnt.

2. Coprolite Works, near Horsecrofts.
From S. B. J. Skertchly's Notes. The top 3 beds seen in the pits.

	Thickness. Feet.	Depth. Feet.
Sand 0 to 2 feet	0 to 2	1 ?
[Chalk Marl] Clunch	12	13
[Chalk Marl] Coprolite-bed, 10 inches ...	say 1	14 about
Gault	90	104
Red sand and rock [Lower Greensand ?] ...	over 12	116

3. Soham Fen. New Schools, Great Drove.
Made and communicated by G. Hook.
120 feet to rock.
Water overflows, but is brackish.

G. Hook has made wells at Soham, about 130 feet deep, into rock [? base of Gault] and then sand, with a good supply of water.

The following details (4 to 6) are from information given by S. J. Ennion, Clerk to the Newmarket R.D.C., to the Local Government Board, in December 1913.

4. Public Pump, near King's Head.
A boring proved insufficient, and the bore-tube was taken out. The dug part of the well was then lined with iron cylinders, 2½ feet in diameter, to the depth of 30 feet, and then dug deeper, 4 feet in diameter, in the Gault and lined with brickwork, to a further depth of 55 feet, down to the Lower Greensand.

5. Fordham Road, near the Cemetery. Bored in 1912.
Lined with 6 inch iron tubes to the depth of 53 feet, and with 4 inch tubes to a further depth of 54½ feet, down to the Lower Greensand.

6. Public Well, Brook Dam Lane, near Red Lion Square, 1913. Boring lined with 12 inch wrought iron tubes to the depth of 30 feet, then with 6 inch tubes to a further depth of 68 feet, in Gault, then punched, but not lined about 24 feet (122 in all) into the Lower Greensand.
For analyses of the water of Soham wells, *see* pp. 128–130.

7. ? Soham or Stuntney. Near Crooked Drain.
Made and communicated by G. Hook.
Shaft 30 feet, the rest bored. No water.
[? Kimeridge] Clay, with thick stones, 130.

Stanton, *see* Long Stanton, p. 80.

Stapleford.

Ordnance Map 205, new ser. (Cambridgeshire 54 N.W. and N.E.).
Geologic Map. 51, S.W.

Vandlebury.—1. Duke of Leeds' garden. 2. Lodge half a mile E. of the Garden. 3. Cot Farm, a mile to S.E.
Communicated by H. Tomlison.

	1.	2.	3.
Height above Ordnance Datum	247	147	113
Depth of well in Chalk	206	97	60
Water-level from surface	199	91	54

Stapleford, *cont.*

4. Windmill.
About 120 feet above Ordnance Datum.
Water stands 53 feet from surface.
Chalk, 63 feet.

5. Dr. Gaskell's, a mile east of Shelford Station. 1891 (originally published as in Shelford).
Made and communicated by G. Ingold.

Shaft 88 feet, the rest bored.
Water-level 86½ feet down.

[Lower Chalk]	Loose chalk	75	118 feet.
	Solid clunch	6	
	Soft chalk	7	
	Hard chalk	30	

Stetchworth.

Ordnance Map 188, new ser. (Cambridgeshire 49, N.W.).
Geologic Map 51, S.E.

1. The Mill. 2. The Village.

	1.	2.
	Feet.	Feet.
Depth of Well	226	236
Chalk at about	150	145
Water-level	201	215

1. A little water came in at 110 feet down.

2. Surface-water came in at 12 or 28 feet down.

3. According to the Local Government Board Return of 1915, p. 97, a bored well, 325 feet deep, supplies part of the parish. The average daily quantity of water got is 21,100 gallons and more than double this could be got. The quality of the water is good: the hardness is 27°, of which 9° is permanent.

For an analysis of the water, *see* p. 130.

Stretham.

Ordnance Map 188, new ser. (Cambridgeshire 30, S.W.).
Geologic Map 51, N.W.

1. Chittering Farm. 1¾ miles S. of the Church.
T. Roberts, "The Jurassic Rocks of Cambridge," 1892, pp. 23, 24, 47, 65. Reproduced in "Jurassic Rocks of Britain," vol. v., pp. 144, 145.

		Thickness.	Depth.
		Feet.	Feet.
Alluvium ...	Peat	5	5
	Sand	3½	8½
Lower Greensand		13½	22
Kimeridge Clay, 51 feet	Black clays, with several bands of greyish limestone, about a foot thick and 3½ feet apart; the clay with some phosphatic nodules	36	58
	Laminated clays, with *Ammonites alternans*	12	70
	Clays with black phosphatic nodules	3	73

Stretham, *cont.*

		Thickness. Feet.	Depth Feet.
Ampthill Clay.	Black, with iron-pyrites: 2 feet of dark sandy limestone near the base	26	99
Lower Calcareous Grit = Elsworth Rock, 19 feet	Hard greyish limestone, crowded with oolitic grains of iron-oxide. *Pholadomya æqualis*	8	107
	Light-brown sandstone	11	118
	Alternating beds of clay and limestone, the latter 8 to 9 inches thick	12	130
	Clays, with fragments of fossils...	57	187
	Clayey limestone	2	189
	Clay, with small pyritized *Ammonite* and *Ostrea*	10	199

2. For the restoration-works at the Church.

From S. B. J. Skertchly's Notes (1874). Water rose 2 feet only; Boulder clay, somewhat sandy, with chalk and flint stones; 2 feet.

Sand [Lower Greensand]: at about 6 feet becomes loamy, by the admixture of dark blue clay; at 15 feet a pebble-bed; quicksand at the bottom.

3. Stretham Fen. Mr. Feust's Farm.

Communicated by Mr. Flavell.

Sand and Gravel	12	30 feet.
Blue Clay. To rock and black sand	18	

A well at Dimmock's Cote is described as in this parish in "The Geology of Cambridge." It is in Wicken, *see* p. 99.

Stuntney.

Ordnance Map 173, new ser. (Cambridgeshire 30, N.E.) Geologic Map 51, N.W.

Mr. Ambrose's. Made and communicated by G. Hook.

Well 40 feet, bored 90.

Fair supply of water; but brackish.

See also under **Soham,** p. 91.

Swaffham Bulbeck.

Ordnance Map 188, new ser. (Cambridgeshire 41.) Geologic Map 51, S.W.

1. Longmeadow. Communicated by Mr. Isaacson.

[Chalk Marl] clunch, with coprolites at bottom...	42	169 feet.
[Gault] Clay	112	
[Lower Greensand] rock and greenish sand, with small pebbles of quartz	15	

2. Longmeadow Farm. (North of).

[Chalk Marl] soil and chalk	15	165 feet.
[Gault] clay	nearly 120	
[Lower Greensand] rock and greensand ...	about 30	

3. Near the Cambridge road.

Made and communicated by G. Hook, of Soham. Bored throughout.

Good supply of water, rising to within 15 feet of the surface.

Chalk, with a bed of coprolites at the base ...	93	196 feet.
Gault, to rock	93	
Sand [Lower Greensand]	10	

Swaffham Prior ?.

Ordnance Map 188, new ser. (Cambridgeshire 41 N.E.)
Geologic Map 51 S.W.
Communicated by Mr. FLAVELL.

[Chalk Marl] soil and white clay	83	203 feet
[Gault and Lower Greensand] blue clay, rock and sands	120	

For an analysis of water from Swaffham Prior, *see* p. 130.

Swavesey.

Geologic Map 187, new ser. (Cambridgeshire 33.)

1. Northern part of the village.

T. ROBERTS, "Jurassic Rocks of Cambridge," 1892, pp. 23, 46.

Clay	23	25 or 26 feet.
Hard brownish limestone (? St. Ives Rock)	2 or 3	

2. Southern part of the village. At end of a long drain. 1885.
T. ROBERTS, "Jurassic Rocks of Cambridge," pp. 44, 45.

Soil and Gravel	1½	23 feet.
Brown and black clay with much selenite, and some fossils. Septarian nodules, 5 feet down	9	
Black clays, with better preserved fossils (list given) and large crystals of selenite	12½	

Thorney.

Ordnance Map 158, new ser. (Cambridgeshire 5, S.E.) Geologic Map 64.

Buke Horn Toll Farm, on the high road W.N.W. of the village, near the county-boundary. 1908.
Made and communicated by Mr. J. E. NOBLE, of Thurlby.

		Thickness. Ft.	ins.	Depth. Ft.	ins.
Soil		2	—	2	—
Gravel		3	3	5	3
[Oxford Clay, 148 feet]	Clay	131	7	136	10
	Clay and small shells ...	7	—	143	10
	Clay	4	6	148	4
	Clay and stone ...	4	11	153	3
[Cornbrash, about 9¾ feet]	Stone	1	5	154	8
	Rock	1	3	155	11
	Hard dark sand and stone	3	5	159	4
	Dark sand	3	10	163	2
[Great Oolite Series, 36½ feet]	Grey bind	8	1	171	3
	Rock	6	5	177	8
	Dark sand	1	7	179	3
	Light-blue clay ...	4	—	183	3
	Green clay	2	—	185	3
	Dark clay	2	4	187	7
	Stone	1	9	189	4
	Clay	1	—	190	4
	Rock	1	—	191	4
	Clay	2	—	193	4
	Rock	6	4	199	8
[Upper Estuarine Clay, about 19½ feet]	Light-blue clay and lime scraps	9	—	208	8
	Dark brown clay ...	7	—	215	8
	Dark blue clay and lime scraps	2	9	218	5
	Clay	—	10	219	3
[Inferior Oolite]	Limestone rock ...	49	7	268	10
	Ironstone	1	—	269	10

Thorney, *cont.*

Water found at a depth of 222 feet, again at 250, and at 261. Overflowed at the rate of 600 gallons an hour. Water poor in colour and salt in character. Became clear later. For analysis, *see* p. 131.

Below 159½ feet the depth is given as an inch more, except at the last when it is given as an inch less.

Trumpington.

Ordnance Map 205, new ser. (Cambridgeshire 47, S.E.)
Geologic Map 51, S.W.

1. Mr. Sayle's. Communicated by Mr. THODAY.

Clunch, with coprolites at bottom	35	195 feet.
[Gault] blue clay	140	
[Lower Greensand] rock and sand	20	

2. Mr. Whitmore's.

Soil and clunch, with coprolites at bottom ...	36	175 feet.
[Gault] blue clay with vein of large coprolites 55 feet from the bottom...	136	
[Lower Greensand] greensand and water ...	3	

Vandlebury, *see* Stapleford.

Waterbeach.

Ordnance Map 188, new ser. (Cambridgeshire 34, N.E., S.E., 35, N.W., S.W., 40 N.E.) Geologic Maps 51, N.W., S.W.

1. Communicated by Mr. FLAVELL.

Black earth	4	? 124 feet.
Blue clay [Gault] to rock and sand	120?	

2. Parish Pump. 1902?
Made and communicated by C. LACK of Cottenham.
Well 30 feet, boring 68, total 98.
Water (from Lower Greensand) 10 feet down in 1902.

3. Waterbeach Fen Chittering Hill? (north of the village).
Communicated by Mr. FLAVELL.

Black earth...	4	51 feet.
Gravel...	1	
[Gault] blue clay	40	
[Lower Greensand] rock and sand...	6	

Welches Dam.

Ordnance Map 173, new ser. (Cambridgeshire 21, S.E.)
Geologic Map 65.

1. Yard belonging to Mr. W. Lyon, three-quarters of a mile W. of Welches Dam (? the village.)

F. W. HARMER, in *Mem. Geol. Survey*, "Geology of the Fenland," 1877, pp. 243, 244. Also noted in *Geol. Mag.*, 1871, vol. viii., p. 144.

[Alluvium]	Peat	5 or 6	?10 feet.
	Clay, with remains of oaks and willows...	1½	
	Reddish sand, with water ...	?3	

This, and other neighbouring wells are notable for having yielded warm water. The temperature of the water was 69° F. on 14 March 1870, that of the air being 39°, that of the water in Vermuyden's Drain 37°, and that of water in ditches close by the yard 38°, the water in both drain and ditches being covered with ice an eighth of an inch thick. "The water is

Welches Dam, *cont.*

evidently heated only at the bottom of the well, as when one first begins to pump, the water comes out cold, and it is only after continuing to pump for a short time that the hot water makes its appearance. . . . . Mr. Lyon . . . . had never known the water to be otherwise than hot, summer or winter."

2. At Fortrey Hall, just within the parish, by the side of Counter Drain, nearly 2½ miles above the village "the underlying stratum (sand) again reached by a pump."

Other shallow wells in which warm water was found seem to be in the parish of Chatteris, but it is convenient to give the account of them here. One is at Horsley Fen Drove (a name not on the Ordnance one-inch map) about 1½ miles S. by W. from Chatteris (Horsley Fen Farm is S. by E.) where the temperature was 51·5°, and the other in a farmyard at Langwood Hill (? New Barn Farm), which was 14 feet deep and wholly in gravel.

These waters were analysed by F. Sutton, from whose remarks "Geology of Fenland," pp. 245, 246) the following notes are taken:—

Source.	Temperature at source.	Solids in grains per gallon.
Lyon's Well	69·	207·89
Fortrey Hall	66·5	279·5
Langwood Hill	74·5	60·74

"What causes the high temperature? The idea first occurring to me . . . . was that, as the wells seem all to be situated in the neighbourhood of farmyards, a species of nitrification was going on in the soil of sufficient intensity to produce the rise in temperature—in which case, of course, there would have been some distinct evidence of it in the water itself. Such, however, was not the case in any instance, there being in none of the samples more than a mere trace of nitrates or ammonia."

"Another possible explanation offering itself previous to the examination of the saline constituents was that the proportion of salts being considerable, some chemical decomposition might be going on between the acids and bases so as to cause a development of heat. But the qualitative analyses of these salts show that they are the same as exist in all ordinary waters, and are not of such a nature as to result in chemical decomposition. Moreover, the sample of water showing the greatest temperature contains by far the least amount of mineral matters." (This one it should be noted is from a well that is wholly in gravel.)

"These suppositions failing to throw any light upon the matter, I am constrained to believe that chemistry can furnish no solution to the difficulty, so far, at least, as the local production of heat is concerned."

One must agree, however, with S. B. J. Skertchly (Memoir, p. 243) in doubting whether the temperature of these waters can be due to deep-seated agencies.

Wendy.

Ordnance Map 204, new ser. (Cambridgeshire 52, S.E. and 53, S.W.)
Geologic Map 51, S.W.

1. Coprolite Works S.E. of the village.
Water overflows.

[Gault] dark clay	115		
[Lower Greensand] Sand	3	120 feet.	
[Lower Greensand] Rock	2		

2. Old North Road, corner of road (on W. side) to the village. 1905? Water (from Lower Greensand) rises (1909) to 2½ feet above the roadway, always flowing at the same rate. A fair supply (? 6 gallons a minute).

3. Old North Road. Road Farm.
Fountain (the water from Lower Greensand). W. W. Gray, 1909.

Weston Colville.

Ordnance Map 205, new ser. (Cambridgeshire 56, N.W.)
Geologic Map 51, S.E.

Dr. W. Armistead. Report to Linton Rural District Council for 1914.
Public pump, with well in Chalk 105 feet deep. One spring used. Also other wells, ponds, and rain-water tanks.
One part of the parish is supplied.

West Wickham *see* Wickham, *and* West Wratting *see* Wratting.

Whaddon.

Ordnance Map 204, new ser. (Cambridgeshire 53, S.W.)
Geologic Map 51, S.W.

1. Coprolite Works.
Communicated by F. J. Carver (Whaddon).

Chalk Marl to coprolites	5 to 30	160 to 215 feet.
Gault clay	150 to 175	
Rock [Lower Greensand]	5 to 10	

2. At Mr. F. J. Carver's house.
Communicated by R. Piggot (well-sinker).
Well 28 feet, the rest bored. Water overflows.

[Chalk Marl] to coprolites...	17	198 feet.
Gault clay	171	
[Lower Greensand] rock and sand, punched ...	10	

3. West of Church, and in front of the Inn.
Water overflows.
Clunch and Gault, said to be 200 or 300 feet.

4. Coprolite Works near King's Bridge, one mile N.E. of the village This may be in the parish of Meldreth.
Communicated by H. Tomlison.

Chalk Marl	15	125 feet.
Gault and rock at bottom	110	

5. In 1909 water (from Lower Greensand) was flowing freely from a boring opposite the Queen Adelaide Inn; 3 feet above the roadway, at the rate of about 12 gallons a minute.

6. A well at the Keeper's Cottage, at the southern end of the avenue of Wimpole Park gave a small overflow (1910).

Whittlesford.

Ordnance Map 205, new ser. (Cambridgeshire 54, S.W. and S.E.)
Geologic Map 51, S.W.

1. Great Eastern Railway Station. 1890.
Made and communicated by Messrs. Le Grand and Sutcliff.
Water-level 10½ feet down (July).

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)		—	12
[Drift]	Light-blue clay and chalk	15	27
	Light-coloured sandy clay	6	33
	Flint and chalk stones	3½	36½
	Light-blue clay	11½	48
	Sandy clay	6	54
	Hard blue clay	5	59
	Stone	2	61
	Clay	1½	62½
Chalk; no flints; a few shells		87½	150

Whittlesford, *cont.*

This section shows the northerly continuation of the Drift channel described in *Quart. Journ. Geol. Soc.*, vol. xlvi. pp. 333–340 (1890).

2. Public Well, 1886. Bored and communicated by G. INGOLD.
Water-level 11 feet down.

		Thickness. Feet.	Depth. Feet.
[Drift]	Gravel	14	14
	Brown marl	10	24
[Chalk]	White chalk, brown in places ...	31	55
	Loose chalk	2	57
	White chalk	28	85

3. Between the Railway Station and the River.
Sunk and communicated by G. INGOLD.

[Drift]	Gravel	13	50 feet.
	Tough sandy blue clay, changing to blue clay, [can this be Boulder clay ?] ...	32½	
	Hard flints	4½	

According to Dr. W. ARMISTEAD'S Reports to the Linton Rural District Council for 1912–1914 there are three public pumps, supplied by tube-wells, bored 80, 85, and 100 feet into Chalk, and lined with from 40 to 50 feet of iron tubes. Other wells, dug into the Chalk, vary from 15 to 162 feet in depth.

4. The Cabin, a mile W. of the Railway Station. 1914.
Sir A. STRAHAN, "Summary of Progress of the Geological Survey for 1914," pp. 65, 66, (1915).
120 feet above Ordnance Datum.
Account from Mr. MAYNARD (with additions from specimens).

		Thickness. Feet.	Depth. Feet.
Top soil and gravel [Post Glacial Drift] ...		15	15
[Glacial Drift.]	Clunch. Water at 120 feet ...	142	157
	Blue clay (specimens, stiff, pale, with minute pellets of chalk) ...	147	304
	Marl (similar material, slightly darker, with dark phosphatic nodules)	59	363
	Lower Greensand, brilliant grass-green when fresh (brown ochry material, with no trace of green, the colour having gone, with round grains of quartz and grains of iron-oxide, but no glauconite)	7	370
	Rock, light-coloured (silty material, pale greenish)	34	404
	Alternate seams of soft and hard materials, varying from pale blue to terra-cotta colour (at 450 feet a specimen of clay, mottled pale blue and red)	46	450
	Some fragments of flint at ...	—	455

"The Boring started at an estimated height of 35 feet above the Melbourn Rock. It should therefore [except for the mass of Drift] have reached the base of the Chalk at about 400 feet and the base of the Gault at about 550 feet."

Mr. MAYNARD says that the flints at 455 feet could hardly have fallen down from the surface, the boring being lined down to 370 feet.

This boring points to a northerly continuation of the deep channel of Drift proved for some miles to the south (*see* Memoir on the Water Supply

Whittlesford, *cont.*

of Essex). "It was anticipated in 1890 by Mr. G. INGOLD . . . that the channel reached northward to Whittlesford, but that a hollow extending to a depth of more than 335 feet below the level of the sea should exist there is surprising."

Wicken.

Ordnance Map 188, new ser. (Cambridgeshire 35, N.E.)
Geologic Map 51, N.W.

1. Dimmock's Cote. On the left (western) side of the Cam, 1½ miles N. of Upware Ferry.

Communicated by Mr. FLAVELL.

[Alluvium]	Black earth	3	141 feet.
	Peat	18	
Blue clay		110	
Rock and sand		10	

In the "Geology of Cambridge" the well is noted as in Stretham, and the clay is classed as Kimeridge. In "Jurassic Rocks," vol. v. p. 146, it is queried as Gault and the bed below as Lower Greensand. The former reading seems the more likely, unless there is a fault, or a deep channel of Gault.

2. Communicated by Mr. FLAVELL.

	Thickness. Feet.	Depth. Feet.
Soil...	3	3
Blue clay	10	13
Black rock	1	14
Blue clay	2	16
Black rock	1	17
Blue clay	5	22
Similar alternations for	178	200

Wickham West.

Ordnance Map 205, new ser. (Cambridgeshire 56, S.W.)
Geologic Map 51, S.E.

1. On the Green, near the White Hart Inn, 1884.

Made and communicated by G. INGOLD.

Some water at 20 feet, more at 36 feet.

[Boulder Clay]	Blue clay	3	40 feet.
	Brown clay	2	
	Blue clay	35	

2. Public Well (with wheel-pump), 1885.

Made and communicated by G. INGOLD.

All dug. Water 121 feet down.

		Thickness. Feet.	Depth. Feet.
[Boulder Clay]	White clay	6	6
	Brown clay	4	10
	Blue clay	38	48
	Clay and chalk	5	53
[Upper Chalk]	Chalk	30	83
	Chalk with occasional layers of clunch	43	126

According to Dr. W. ARMISTEAD'S Reports to the Linton Rural District Council for 1912–1914 another public pump is supplied from a spring. Ponds are used.

Wilbraham, Great.

Ordnance Map 205, new ser. (Cambridgeshire 48, S.)
Geologic Map 51, S.W.

Well at Fleam Dyke, for the Cambridge Water Works Co., 1912.
Made by Messrs. Docwra. Communicated by W. W. Gray.
98 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Soil		3	3
[Lower Chalk]	Jointy chalk. No flints ...	45	48
	Wet harder chalk	3	51
	Jointy chalk. No flints ...	24	75
	Totternhoe Stone	17	92
	Loose grey jointy chalk ...	23	115
	Harder chalk	26	141
	Close hard grey chalk ...	10	151
	Grey chalk, to bottom of well	8	159
Boring (6 inches diameter) reached Gault at ...		—	215

Willingham.

Geologic Map 187, new ser. (Cambridgeshire 33, N.E., S.E.)

1. Cold Harbour Farm. S.W. of the village.

From A. C. G. Cameron's Notes.

Dug. 22 feet. No water.
Solid clay 30 feet.

2. Mill house, adjoining the windmill, on the main road, S. of the village ?

From A. C. G. Cameron's Notes.

Loamy clay	4 to 5	25 feet.
Gravel and water	½	
Heavy blue clay	20	

On the M.S. Geol. Survey Map (Cambridgeshire 33, S.E.) the depth is given as 40 feet.

3. Water Company.

Local Government Board Return for 1915, p. 242, and from information given to that Board by C. T. Lack.

Supplies part of the parish from a well.

Average daily quantity of water available 70,000 gallons. The quality is satisfactory.

Pumping station 23·8 feet above Ordnance Datum.

Well covered by slab of reinforced concrete with a manhole at top, of 3 feet diameter, covered with a concrete slab, below soil shaft of 10 feet internal diameter, made of brickwork in cement from 5½ feet down, to about 12½, when it fits over a shaft of 8½ feet internal diameter, 7 feet made of dry brickwork, with a brick bottom.

Soil...		1½	21¾ feet.
[? River Drift.]	Fine sand	13¼	
	Coarse sand	7	

Wimpole.

Ordnance Map 204, new ser. (Cambridgeshire 53, N.W.)
Geologic Map 51, S.W.

1. Coprolite Works

[Gault] blue clay	175	187 feet.
[Lower Greensand] rock and sands, varies, about	12	

2. Coprolite Works, near the Ruins.
Sunk 120 feet, the rest bored.
Water, 80 feet from surface.
Clunch and Gault, 180 feet

Wimpole, *cont.*

3. Old North Road, Estate Manager's Garden.

A boring, into Lower Greensand, supplying a fountain, with a large basin, used for the garden in summer. W. W. Gray, 1909.

4. Opposite cottages near Estate Office.

The water (from Lower Greensand) was about a foot above ground-level, with a fair supply; but it lowers occasionally, probably from pumping at Wimpole Brewery. W. W. Gray, 1909.

My note (April, 1910) gives a flow of about 6,000 gallons a day to No. 4, on the southern side of the road going E.N.E., and but little off No. 3 which is at the junction of the roads and with about half that yield.

Wood Ditton.

Ordnance Map 188, new ser. (Cambridgeshire 49, N.E.) Geologic Map 51, S.E.

Saxon Street. Public Well. 1892.

Made and communicated by G. Ingold.

Shaft 186½ feet, the rest bored. Water-level 183 feet down.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	White clay	10	10
	Blue clay	50	60
	White clay	3	63
	Red sandy loam	½	63½
	Brown clay	9	72½
	Red sandy loam	2½	75
[Upper Chalk]	Soft chalk, with layer of flints at the base	60	135
	Clunch	3	138
	Chalk	4	142
	Clunch	3	145
	Chalk, with layer of flints and *Terebratulæ* at 186½ feet	91½	236½

Wratting, West.

Ordnance Map 205, new ser. (Cambridgeshire 56, N.W.) Geologic Map 51, S.E.

1. By Roadside on the Common. 1885.

Bored and communicated by G. Ingold.

Boulder clay, 51 feet. No water.

2. Public Well, near the church (with wheel-pump) 1885.

Made and communicated by G. Ingold.

All dug. Water rose to within 142 feet of the surface.

		Thickness. Feet.	Depth. Feet.
[Boulder Clay]	Brown and yellow clay	19	19
	Brown clay and clunch	15	34
[Upper Chalk]	Chalk-rock [?chalk hardened by infiltration]	12	46
	Chalk with a few flints	49	95
	Hard clunch	2	97
	Clunch and chalk	28	125
	Hard clunch	8	133
	Chalk with layers of clunch ...	16	149

WELLS AND BORINGS IN HUNTINGDONSHIRE.

Abbots Ripton.

Ordnance Map 172, new ser. (Hunts. 14, S.W.) Geologic Map 52, N.E.

1. The Hall.

Boring, made by Messrs. WENHAM and WATERS, of Croydon.
? about 1890.

Thought to be about 200 feet deep.
Water, salt.

2. Railway Station.

Trial-boring, made by the DOWLAIS Co. About 1890.

Water, salt.

In both of these, much pyrites was found in the clay, and seams of lignite (?) which would not burn, according to LORD DE RAMSEY.

Bluntisham.

Geologic Map 187, new ser. (Huntingdonshire 19, N.E. and S.E.)

1. Northern side, 1874. 32 feet deep.

From S. B. J. SKERTCHLY'S Notes.

The top part, dark bluish Boulder Clay full of striated chalk stones
Kimmeridge Clay beneath (?).
Oxford Clay at the bottom part, *Gryphæa dilatata* being abundant, with an extraordinary number of *Ammonites*, too fragile to be got out.
The base, a floor of light-brown water-bearing septaria.

2. Mr. Tebbuts.

Very little water; drains in from hard beds.
Oxford Clay, with hard bands, 300 feet.

Bury.

Ordnance Map 172, new ser. (Huntingdonshire 10, S.E.) Geologic Map 64
Pioneer Potato Products Co. Just outside Ramsey Railway Station, S.W. of the line.

Made by Messrs. ISLER & Co.

Communicated by T. DORRINTON of Wistow.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Surface earth		2	0	2	0
[? All Oxford Clay]	Brown clay	12	0	14	0
	Blue clay or gault	131	0	145	0
	Hard shale	1	0	146	0
	Blue clay or gault	18	0	164	0
	Hard shale	2	6	166	6
	Blue clay or gault	1	6	168	0
	Hard rock or shale	11	0	179	0
	Blue clay	3	0	182	0
	Green clay or gault	3	6	185	6
	Blue clay	66	6	252	0
	Hard rock	3	0	255	0
	Blue clay, with 3 ins. of hard rock at 318 and 338 feet	115	0	370	0
	Hard rock	1	0	371	0
	Blue clay	2	0	373	0
	Hard rock	2	0	375	0
	Blue clay	25	0	400	0
	Hard rock	2	0	402	0
	Blue clay	71	0	473	0
	Hard rock	2	0	475	0
	Blue clay	35	0	510	0
[? Great Oolite]	Hard rock	1	0	511	0
	Blue rock	29	0	540	0

Bury, *cont.*

The thickness herein given to the Oxford Clay is far greater than what is suggested in the Ramsey boring (p. 106), though but little distance from it. There are marked stony beds in the Oxford Clay in this neighbourhood, one being well shown in the large pit near Warboys Station, where it is big enough to be worked for lime.

Catworth.

Ordnance Map 186, new ser. (Huntingdonshire, 16, S.E.)
Geologic Map 52, N.E.
From A. C. G. CAMERON'S Notes.

Manor Farm, N.E. of the village.

Well, 12 feet through chalk [large transported mass] over Oxford Clay.

T. S. DYMOND writes (1920), that all but one of the wells in this village go dry in summer.

Covington.

Ordnance Map 186, new ser. (Huntingdonshire, 16, S.W.)
Geologic Map, 52, N.E.

According to A. C. G. CAMERON, the wells here are dug about 30 feet and bored about 30 feet [in Boulder Clay].

East Huntingdonshire Water Company.

From Local Government Return of 1915, p. 188.

Supply from Bourn in Cambridgeshire, *see* p. 56.

Supplies Bourn (part), Knapwell, Long Stowe (part), and Swavesey (in bulk) in Cambridgeshire; Fen Stanton (part), and St. Ives (in bulk), in Huntingdonshire.

The limits of supply are much wider.

Daily average, 27,000 gallons and 36,000 in bulk

According to the Waterworks Directory, 1911, p. 313, wells and borings from 117 to 50 feet above Ordnance Datum, into Lower Greensand.

Water of a high degree of purity, rather hard, contains iron.

Yearly supply 20,000,000 to 23,000,000 gallons. Average daily supply per head, 10. Maximum day's supply in July, 85,000. Population supplied about 5,000.

Farcet.

Ordnance Map 172, new ser. (Huntingdonshire, 5, N.E.)
Geologic Map 64.

Just N.W. of the Church (?), 1899. No water.

Boring made and communicated by J. E. NOBLE. Classification by H. PRESTON.

26·6 feet above Ordnance Datum.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Soil		4	0	4	0
Gravel		3	6	7	6
Boulder Clay and Oxford Clay	Clay knots	47	6	55	0
	Blue sand	7	0	62	0
	Clay	5	6	67	6
Cornbrash.	Rock	6	0	73	6
Great Oolite Clay		8	6	82	0
Great Oolite Limestone nearly 14½ ft.	Rock	2	0	84	0
	Clay	1	0	85	0
	Rock	11	4	96	4
Lower Estuarine Series, over 31 ft.	Clay	14	2	110	6
	Black sand	17	0	127	6
Lias Clay, 3 inches of rock below 180½ feet...		101	6	229	0

Great Paxton, *see* Paxton.

Godmanchester.

Geologic Map 187, new ser. (Hunts. 22, N.W.)

What we learn from W. LEE's Report to the General Board of Health, in 1849, probably holds to the present day, as regards the supply of water, the gravel of the place and its surroundings being now as then the only local source of water, other than any taken from the Ouse, or as rain.

Wells dug to a depth of six or eight feet are said to yield a continuous supply; but the water is hard, and the writer says: "The general purity of the subsoil water within a few feet of the surface of a town like Godmanchester cannot be insured, even under the best sanitary arrangements, to such an extent that the inhabitants should be compelled to use it for culinary purposes."

Information from the Local Government Board, (1918 ?):—An abundant supply is said to be got from wells. Two houses get a supply from ponds, and one house from a rain-tank. The water is liable to pollution.

Hilton.

Geologic Map 187, new ser. (Huntingdonshire 22, S.E.)

Red Hill Farm, eastward of the village.

A note on the six-inch map says that a well here is in stone (Elsworth Rock) in clay.

Huntingdon.

Geologic Map 187, new ser. (Huntingdonshire, 18, S.W.)

Well in gravel of Ouse Valley. Average daily supply 89,500 gallons, which could be increased largely.

Supply constant. Quality of water good. Hardness 26·4°. (Local Government Board Return of 1915, p. 68).

In the first place it is to be noted that the water-supply of the county-town is of a somewhat peculiar sort. It cannot strictly be called a well-supply, unless long trenches in gravel are looked on as a continuous well (which they are in effect), and it might be taken as a supply from artificial springs, its origin being so near the surface.

I had the advantage of seeing the works in 1919 with J. D. HAWORTH, the engineer who was consulted as to their improvement and extension.

The abundant sheets of gravel in the neighbourhood are practically the only available sources of water, other than such supplies as could be taken direct from streams. There is great uncertainty as to the thickness of the Oxford Clay, in the absence of borings in the district that have been carried through this formation to the limestones beneath: we have no evidence of the sort from nearer than Ramsey, more than eight miles N.N.E., where the limestones may have been reached at the depth of something under 300 feet; but information lately to hand seems to throw some doubt on this, and to give the Oxford Clay a much greater thickness (*see* p. 102). The outcrop of the limestones is some twelve miles from Huntingdon, northward.

There is also much doubt as to the quality of any water that might be got from the limestones at a considerable depth: it might be salt.

The original works are on the left or northern side of the Alconbury Brook, where, on the advice of E. EASTON, a well was sunk in 1874, with a satisfactory result.

This well, just west of the Great Northern Railway Station, is in gravel, and pipes were laid along the meadow further westward, to collect springs from the gravel.

The quantity of water found was more than was wanted at the time, and the quality was good, Dr. VOELCKER saying that, though hard, the water was very pure.

In 1883, however, these works were found to give too small a yield, and Mr. EASTON advised crossing to the other side of the Alconbury Brook,

Huntingdon, *cont.*

which was done, and a site was acquired bounded on the north by that stream, on the west by the Brampton Brook, on the south by the Ouse, and on the east by the Great Northern Railway.

Trenches were dug into the gravel in the northern part of this area, and the water was led in pipes across the Alconbury Brook to the pumping station.

At a later date (1902 ?) further additions and improvements were made on the advice of R. E. MIDDLETON and the supply is now got wholly from the tract south of the Alconbury Brook, the original works, to the north, being used only for the collection of the water into tanks, about a hundred yards from the pumping station, the well at which is now only a pumping well.

As yet, however, only the northern part of this irregular triangular area has been used; but it is proposed to extend the trenching over this and if needful over the southern part, so as to increase the yield; and, in order to test the ground, as to the character of which there was no record, four holes were dug in May, 1919, with the following results:—In all the top earth varies from sandy clay to sandy loam; there is nothing of the ordinary marsh-clay and peat of the River Alluvium, and in all it was dry. In all clearly the beds passed through form a good filtering material.

No. 4. About 1,775 links S.W. of the old well (by the side of the river just west of the railway) 35·58 feet above Ordnance Datum. Water about 7 feet down.

Sandy loam, brownish	4 or 5 feet.
Fine gravel, mostly flints, with sand (sharp, rather coarse) the whole very clean, light-coloured	2 to over 3 feet

No. 1. About 1,475 links south-south-west of the old well and about 50 from the railway. 33·23 feet above Ordnance Datum. No water when I was there; but there has been some. Top as in No. 4, up to 3 feet. Gravelly sand, clean to the depth of 4½ feet and driven into for another foot.

No. 3. A little over 700 links in the same direction as No. 1, and the same distance from the railway. 33·84 feet above Ordnance Datum. Water 29·05. Top, as above, 2½ to 3½ feet. Fine sandy gravel, as above.

No. 2. About 675 links further and almost in the same direction as No. 4. 33·89 feet above Ordnance Datum. Water 29·48. Soil here up to a foot thick, but no clear division from the bed below which is as in the above, about 4½ feet. Sand and gravel touched. Driven into about a foot.

Orton (or Overton) ? Longville or Waterville.

Ordnance Maps 158, 172, new ser. (Huntingdonshire 2, S.E. or 5 N.W. or N.E.) Geologic Map 64.

JUDD, "Geology of Rutland, &c.," 1875, p. 209.
Reprinted in "Jurassic Rocks," vol. iv., p. 415.

Cornbrash.
Great Oolite Clay, 13 to 14 feet.
Great Oolite Limestone, 17 feet.
Upper and Lower Estuarine Series, 39 feet.
Northampton Sand. Ironstone-rock.
[Apparently over 70 feet in all.]

Orton Longville gets a supply from Peterborough.

Orton Waterville. According to the Rector, the Rev. W. P. RIGG, writing in March 1915, the water of the principal wells was condemned in 1914 by the Medical Officer of Health, but, with few exceptions, the water is still used for drinking purposes.

Orton Waterville.

A report by W. M. CROSS to the Chief Engineer, Local Government Board, 28 July, 1914, says that the water-supply is got from wells, from

Orton Waterville, *cont.*

about 10 to 50 feet deep. There are said to be 38 of them. In some cases privy-middens are close to the wells, and probably, being old, are not water-tight. In March 1914, nine cases of diphtheria were notified. Analyses of the water from four wells in the village were made in the latter part of January, and in all cases the water seemed to be polluted with sewage and was unfit for drinking purposes. Some of these wells were cleared out, but the analyst's observations on the fresh analyses which were made did not vary.

In two cases wells were close to large farmyards, covered with manure.

Paxton, Great.

Geologic Map 187, new ser. (Huntingdonshire 25, N.E.)

Public Supply.

Local Government Board Return, 1915, p. 124.

Well in gravel (of the Ouse) overlying Oxford Clay.

Average daily quantity of water got 5,000 gallons, and a further 30,000 could be got.

Quality of water very good. Hardness about 19°.

Ramsey.

Ordnance Map 172, new ser. (Huntingdonshire 10, S.E.)
Geologic Map 64.

1. The then Cricket Field (now partly built over). The site is on the western side of the road a little N.N.W. of Joint G.N. and G.E. Railway Station. Boring, 1885.

Details from A. C. G. CAMERON, "Jurassic Rocks," vol. v., p. 60.

		Thickness. Feet.	Depth. Feet.
Alluvial Soil		128	128
Oxford Clay and Great Oolite Series?	Clay		
	Rock } Clay }	33	161
	Hard Rock (pyrites)	20	181
	Clay	22	203
	Chalk and rock	8	211
	Clay, moist	46	257
	Rock	11	268
	Clay	15	283
	Rock	20	303

e H. B. WOODWARD adds that the boring "failed to find water; nor could it reasonably have been expected at such a depth, as the sinking was commenced in the Upper Oxfordian Beds, and considering the argillaceous nature of the Great Oolite divisions, no reliance could be placed on them as water-bearing." He does not venture to mark the division between the two formations.

According to Dr. SWEETING's Report to the Local Government Board (1909) the water was too brackish for use.

2. For the District Council.

Made and communicated (1901) by Messrs. ISLER & Co.

Sandy clay and gravel	16	22 feet.
Chalk (? Boulder)	4	
Blue clay	2	

e There is no piped service, and apparently little in the way of a public supply.

St. Ives.

Geologic Map 187, new ser. (Huntingdonshire 18, S.E.; 19, S.W., 22, N.E.; 23, N.W.)

Supplied by the East Hunts. Water Co.
Waterworks Directory, 1911, p. 313.
Population supplied given as 2,910.
According to the *Local Government Board Return*, 1915, p. 436, wells are shallow but plentiful.

St. Neots.

Geologic Map 187, new ser. (Huntingdonshire 25, S.E.)

1. Paper Mills. By the Ouse, N. of the town.
A well here, 300 feet deep, yielded saline water (chloride of sodium and sulphate of soda), according to H. B. WOODWARD, "Jurassic Rocks," vol. v., p. 341.

2. Waterworks, Eynesbury, S. of the town, 1907.

Local Government Board Return, 1915, p. 124.

Well in gravel.

Average daily quantity of water got, 89,000 gallons; 136,000 more could be got. Supply constant.

A quarterly chemical examination of the water is made. The analyst says that the water is pure. Hardness, 18°.

Besides the town the parishes of Eynesbury and St Neots Rural are supplied.

According to the *Waterworks Directory*, 1911, pp. 313, 314, the well is 30 feet deep, the population supplied was 4,000, and the yearly supply was 30,000,000 gallons.

The following particulars are from further information, given to the Local Government Board:—

The pumping station is 56¾ feet above Ordnance Datum.
No. 1 well is 20 feet deep and of 9 feet diameter.
No. 2 is 17½ feet deep, and of 4½ to 5½ feet diameter.
No. 3 is 17 feet deep, and of 8 feet diameter.

They are connected by 12-inch collecting drains, running west from the pumping station. No. 1 being connected to No. 2 by 100 yards of drain 17 feet down, and No. 2 being connected with No. 3 by 55 yards of drain, 16½ feet down.

31 March 1914. Rest-level 7 feet 4 inches down. Level after pumping 7 hours, 9 feet 8 inches.
19 January 1915. Rest-level 5 feet 2 inches down. Level after pumping 7 hours, 8 feet 3 inches.

Somersham.

Ordnance Map 172, new ser. (Huntingdonshire 15, S., 19 N.)
Geologic Map 51, N.W.

Park Farm.
Information from G. INGOLD, 1898.

(? Gravel, or soil, &c.) ...	...	...	...	...	12	137 feet.
Blue [Oxford] Clay ...	...	...	...	...	125	

Staughton, Great.

Geologic Map 187, new ser. (Hunts. 21, S.W.).

Dillington, a hamlet north-eastward of the village.

From the Report of the Medical Officer of Health for 1912.

18 houses, supplied from 5 wells, 4 ponds, and rain-water. The wells are shallow, the water is brackish, and some of it undrinkable. All wells liable to surface-pollution. The pond-water is unfit for drinking or domestic purposes ; it is preferred to well-water.

Wansford.

Ordnance Map 157, new ser. (Huntingdonshire 1). Geologic Map 64.

For Stibbington Rural District, 29 chains N.W. of Wansford Church, at the junction of the King's Cliffe and Leicester Roads. According to the position of the site (across the Nene), this seems to be in Northamptonshire ; but the church of Wansford, and apparently part of the parish, is on that side of the river.

From the Local Government Board.

100·27 feet above Ordnance Datum.

Yield, found by continuous pumping for 36 hours, 21,600 gallons a day.

Level of water at beginning of pumping, 94·27 feet above Ordnance Datum, at cessation of pumping, 83·27.

Time taken for water to return to rest-level after pumping ceased, 1¼ hours.

		Thickness. Feet.	Depth. Feet.
Soil		1	1
[Lincolnshire Limestone]	Rock	10½	11½
[Northampton Sand] ...	Ironstone	5½	17
	Sandstone	5	22
[Upper Lias]	Clay and stone ...	6	28
	Blue clay	14	42

WELLS AND BORINGS IN RUTLAND.

Barleythorpe.

Ordnance Map 157, new ser. (Rutland 5, S.W., 9 N.W.).
Geologic Map 64.

Springfield. The house here is just in the Parish of Barleythorpe, and about half a mile northward of Oakham.

Bored and communicated by Messrs. MERRYWEATHER.

Little water found. Well not used.

	Thickness. Feet.	Depth. Feet.
Gravel	2	3
Hard scale	3	5
Blue stone	2	7
Blue clay	12	19
Rock	1	20
Blue clay	6	26
Hard rock	2	28
Blue clay	14	42
Hard blue clay	4	46
Blue clay, with hard rock at 51½ to 52 ...	10	56
Hard blue clay	2	58
Blue clay	42	100

Barrowden.

J. E. O'CONNOR, M.O.H., says in his Annual Report for 1913, p. 4:—"In Barrowden most of the wells are polluted, and a public supply is much to be desired."

Braunston.

Ordnance Map 157, new ser. (Rutland 9, N.W.). Geologic Map 64.

Oakham Waterworks. Between road and river about half a mile eastward of the village. 1913? About 350 feet above Ordnance Datum. Water from two wells within a short distance of each other. Average daily quantity, 57,000 gallons.

Spring marked on map just W. of road and a little S. of the Gwash in the parish of Brooke, by the side of Brooke Priory.

Another on E. side of road about half a mile N.E. of the village of Braunston.

Brooke.

Ordnance Map 157, new ser. (Rutland 9, N.W.). Geologic Map 65.

Private Boring, 1913.

Made and communicated by J. E. NOBLE.

No water got.

Soil	1	65 feet.
Clay and chalk [Boulder Clay?]	2	
Upper Lias	62	

Essendine.

Ordnance Map 157, new ser. (Rutland, 7). Geologic Map 64.

Private Bore, 1905.

Made and communicated by J. E. NOBLE.

Good supply. Water-level, 66 feet down.

	Thickness.		Depth.	
	Ft.	Ins.	Ft.	Ins.
Soil	1	6	1	6
Rock	4	3	5	9
Sand	0	8	6	5
Rock	2	0	8	5
Clay	5	1	13	6
Rock	1	0	14	6
Clay	5	2	19	8
Rock	1	0	20	8
Clay	25	6	46	2
Rock	85	9	131	11

Hambleton.

Ordnance Map 157, new ser. (Rutland, 9). Geologic Map 64.

Boring, 3 miles E.S.E. of Oakham.

Communicated by ROB. GRIGGS, 1882. Classification by H. B. WOODWARD.

		Thickness. Feet.	Depth. Feet.
Northampton Sand		10½	10½
Upper Lias clay		176	186½
Middle Lias.	Marlstone rock	15	—
	Clay	3	—
	Rock	1	—
	Clay	12	—
	Rock	1	—
	Clay	16	—
	Rock	1	—
	Clay	4½	240

Water was found in the lower part of the Marlstone, but not in great quantity. An increased quantity was found in each of the three bands of rock below. The water-level stood about 6 feet above the bottom of the Marlstone.

Ketton.

Ordnance Map 157, new ser. (Rutland 10, S.E.) Geologic Map 64.

For C. F. Burroughs. Boring. S.E. side of Bushey Closes, 1920, 1921. About 250 feet above Ordnance Datum.

Communicated by T. H. BURROUGHS to C. B. WEDD.

		Thickness. Feet.	Depth. Feet.
Soil		2	2
Drift Clay		7½	9½
Great Oolite.	Hard rock	4½	14
	Rubble	4	18
	Yellow clay	3½	21½
	Blue marl (Water)	7	28½
	Freestone	2	30½
	Blue clay	4	34½
	Freestone	2½	37

Ketton, *cont.*

		Thickness. Feet.	Depth. Feet.
Upper Estuarine Series.	Blue clay	9	46
	Brown clay	9½	55½
	Yellow marl	3¾	59¼
Lincolnshire Limestone.	Rock	4¾	64
	Clay	1	65
	Rock	5	70
	Rubble	1	71
	Hard rock	28¼	99¼
Lower Estuarine Series and Northampton Sand.	Yellow sand (Water)	4¼	103½
	Rock	12½	116
	Brown clay	1	117
	Loamy sand	2	119
	Grey sand	1	120
	Red marl	4½	124½
	Ironstone rubble	2	126½
	Red sand	5	131½
Upper Lias.	Blue marl	3½	135
	Rock	1½	136½
	Red marl	1	137½
	Blue clay	22	159½
	Clay stone	1	160½
	Blue clay	5½	166
	Clay stone	1	167
	Shale	45	212

The classification by C. B. WEDD.

The position was chosen by divining, the diviner predicting a large supply at 100 feet, or a little more. Some water, but not much, was got at that depth, from the sand. The boring was continued without getting any more water.

Said to have been continued 20 ft. deeper (1921) and has got water at that depth, evidently from the Marlstone rock-bed, the Upper Lias being only about 100 feet thick.

Langham.

Ordnance Map 157, new ser. (Rutland 5). Geologic Map 64.

Langham Brewery. 1901.

The Boring made and communicated by Messrs. ISLER & Co.

Lined with 95 feet of tubes, of 7¼ inches diameter, 10 feet down. Water-level 32 feet down (? in the boring).

Well, old	77	318 feet.
Blue marl, with 6-inch layers of hard stone, below 115, 142, 179, 180½, 184½, and 188 feet... ...	241	

Manton.

Ordnance Map 157, new ser. (Rutland 9, S.W. and S.E.). Geologic Map 64.

1. 30 yards west of the Church, 1913.

Bored and communicated by J. E. NOBLE.

No water got.

Made ground	4	80 feet.
Sand	2½	
Ironstone	4	
Upper Lias Clay	69½	

Manton, *cont.*

2. A private Boring, 1913, made and communicated by J. E. NOBLE. No water got (meaning no supply).

Soil	2	
Sand	7	
Ironstone	5	28 feet.
Sand (water)	2	
Upper Lias Clay	12	

Market Overton.

Ordnance Map 143, new ser. (Rutland 2, S.E.). Geologic Map 64.

Two trial-borings for water, on the brow of the Liassic escarpment 1915. From H. PRESTON (Report of the Sectional Officer of the Lincolnshire Naturalists' Union.)

1. On N. side of road a little N.E. of the village.
Soil and Northampton Sands (ironstone) a few feet.
Upper Lias Clay, just over 150 feet, without finding marlstone.
Total 159 feet.

2. On W. side of lane, N. of same road, nearer village. Soil and a few feet of Northampton Sand (ironstone).
Blue Clay (Upper Lias) then 36 feet of stone and clay. Total depth 300 feet. No Water. A diviner who was called in had predicted an abundant supply. Mr. PRESTON thought that some water would be got from the Marlstone, as there is plenty of water in that rock at the outcrop near by. He believes that some disturbance may have broken it up.

Oakham.

Ordnance Map 157, new ser. (Rutland 9, N.W., 5 S.W.). Geologic Map 64.

In "Sanitation of the Town of Oakham. . . . Report of the Medical Officer, J. E. O'CONNOR," 26th January 1908, p. 3: "Owing to shortage and to contamination of surface wells a satisfactory supply was installed by a private Company in 1901. . . . The water is ample in quantity and of a high degree of purity, its one main fault being . . . . hardness, which is, however, artificially reduced to 9 degrees." Nevertheless, "but little more than a third of the houses obtained their drinking water from this source. . . . As to the remainder . . . . shallow wells form the principal, indeed the almost sole, source of supply. In the vast majority of instances these wells are constructed of loose 4½-inch brickwork . . . . without that adequate protection from percolation, which is so essential in the upper six or eight feet of most wells. . . ."

"Eighty seven samples (of the waters) furnished marked indications of contamination with animal organic matter the majority being heavily polluted. Of the remaining 18, only three could be regarded as really passable."

Various MS. Returns (at Ministry of Health) show like conditions in various villages in the Oakham Rural District:—

Ashwell; deep wells found polluted.
Hambleton; deficient in quantity and quality.

1900 { *Greetham*; good public supply.
Langham, Manton, Thistleton; public supply.
Tickencote; public well.

OAKHAM WATER CO.
From the Ministry of Health.

Parishes within limits:—

Oakham	supplied.
Ashwell...	not supplied.
Barleythorpe	supplied.
Braunston	partly supplied.
Brooke	not supplied.
Burley	partly supplied.
Egleton, Ganthorpe, Hambleton, Langham, Manton and Martinsthorpe	not supplied.

Oakham, *cont.*

A mile west of Oakham. This may therefore be in the parish of Barleythorpe. About 1874.

About 350 feet above Ordnance Datum.

Shaft throughout; 7 feet diameter.

Water-level 40 feet down; not perceptibly reduced by pumping.

Rep. Brit. Assoc. for 1879, p. 161, Section reproduced in "Jurassic Rocks," vol. iii, p. 238. Also in "The Geology of the Country near Leicester," p. 94.

Drift		4	80 feet.
Upper Lias Clay		30	
Middle Lias	Marlstone rock	18	
	Sands	28	

"Very sweet and pleasant water; used solely for brewing."

Ridlington.

J. E. O'Connor, M.O.H., in Annual Report for 1904, p. 9, speaks of this as "a village whose past health record includes a severe outbreak of Enteric Fever attributed to pollution of wells."

Ryhall.

Ordnance Map 157, new ser. (Rutland 7, N.E.). Geologic Map 64.

Belmesthorpe Grange. Hamlet S.E. of village, 1909.

Boring made and communicated by J. E. Noble, of Thurlby.

Water-level 60 feet down.

A very good supply of pure water from the bottom rock.

	Thickness.		Depth.	
	Ft.	Ins.	Ft.	Ins.
Soil	1	—	1	—
Stone and clay	1	6	2	6
Clay	15	6	18	—
Stone and clay	4	—	22	—
Rock	16	8	38	8
Clay	18	3	56	11
Marl	33	4	90	3
Rock	39	9	130	—

Somerby.

Geologic Map 156, new ser.

Sixth Rep. Riv. Poll. Comm. 1874, p. 394:—

"This parish. . . . . derives its water from shallow wells. The town well supplying the end of the village furnished a fairly good water for drinking but it was harder than desirable for washing. Plants' pump water was inferior to the last, but still it was as good well water as is usually met with near human habitations. It was excessively hard and quite unfit for washing. If these wells were carefully guarded from surface soakage their water might be drunk with but very slight risk to health. The remaining samples were but little else than sewage which had percolated through a porous soil into the wells."

Entered here by mistake. The place is in Leicestershire.

Uppingham.

Ordnance Map 157, new ser. (Rutland 13 E.). Geologic Map 64.

In his Annual Report to the Uppingham Rural District Council for 1903 J. E. O'Connor says (pp. 2, 3):—

"The School and Town of Uppingham have been supplied with a wholesome water, which, however, in recent years has proved inadequate."

"In 1899 experimental work in the Welland valley, some four miles south of Uppingham, showed that an ample supply of water could be obtained, and in 1902 a well was sunk in a field. . . . The yield was tested up to

Uppingham, *cont.*

300,000 gallons a day, and two samples . . . . proved to be of a high standard of organic purity. . . . The only fault in the water was its hardness . . . . chiefly . . . . due to the presence of carbonate of lime, and removable. . . . The installation for carrying out this process has now been provided, the hardness of the water being reduced from 29 to 7 parts per 100,000."

"The well is situated in the open country far away from any house, building, or arable land, the nearest village or ploughed field being about a mile away."

WATERWORKS CO.

From the Ministry of Health.

Wells in a grass field on high ground, Uppingham. In Northampton Sand, Minimum daily yield 12,000 gallons in summer and 20,000 in winter. Average daily quantity got from the source 10,000 (?).

There are shallow wells (for waterworks) near the deep boring and mainly on the western side of the Workhouse, which are not used for drinking. The only well that is now used (for swimming bath) is immediately north and close to the deep boring, about 490 above O.D.

The Gretton well is about 100 yards within that Northamptonshire parish (Sheet 171 of the Ordnance Map) in the middle of the alluvial flat of the Welland, four miles from Uppingham, and just S. of Middle Bridge, about 153 feet above Ordnance Datum. It is 20 feet deep, in alluvial soil [? and gravel] and is the only drinking-supply of the Company. The daily yield is 200,000 gallons, and the average quantity daily taken throughout the year is 70,000. Supply constant.

Waterworks, 1883. From ROB. GRIGGS, Architect.

Well 200 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Mould		2	2
Boulder Clay		2	4
Inferior Oolite. Northampton Sand.	Ferruginous sand and sandstone, locally termed "Kale," hardening into blue rock. Water	10?	16
	Undescribed	2	18
	"Trough" very hard blue rock	2	20
	Cockle-bed	½	20½
Upper Lias.	Dark blue clay, with nodular limestone, iron-pyrites, and shale-beds, hardening as the depth increases	173½	194
	Serpentinus beds, very full of fossils	3	197
	Blue clay, like that above ...	35	232
Middle Lias, or Marlstone and Lower Lias.	Hard white rock, 12 inches. Two layers of rock, each 4 inches. Clay between 2 inches ...	2	234
	Clay as above	6	240
	Hard rock, limestone	2	242
	Clay	8	250
	Rock, 9 inches, and clay 3 feet 3 inches	4	254
	Soft sandy clay	4	258
	Clay	4½	262½
	Hard rock, limestone	1¾	264¼
	Clay	14¾	279
	Two layers of rock, with clay between, all 4 inches ...	1	280
	Clay, with thin layer of green sand at 298 feet	32	312

Uppingham, *cont.*

Trial-boring. 1876. About 70 yards south of the Workhouse.

From H. B. WOODWARD'S Notes.

	Thickness. Ft.	Ins.	Depth. Ft.	Ins.
About 25 feet of sand above the Lias ...	—		25	0
Upper Lias. Greyish stone-bands and balls every foot or so	? 188	0	213	0
Dark bands of stone, 2 or 3 ins. thick and 2 or 3 to a foot	22	0	235	0
Much the same, but with iron-pyrites ...	3	6	238	6
Iron-pyrites	1	4	239	10
Strong clay, but much the same	5	0	244	10
Strong dark clay (calcareous ?), with bits of flinty stone...	5	0	249	10
Strong clay, with white specks, and a dark blue band 6 ins. thick	5	0	254	10
Much harder, with white specks and bands of pyrites, 2, 3, and 6 ins. thick	5	0	259	10
Continued in clay	140	2	400	0

In the Memoir on the "Jurassic Rocks," vol. iv., p. 195, WOODWARD gives the following section of a well in the town. It may be a detailed account of the top line of the above, or of one of the shallow wells close by, westward of the Workhouse:—

Lower Estuarine Beds, sand and clay ...	12		
Northampton Sand	Ironstone-rock ...	5 to 6	24 to 25 feet.
	Rock, Building-stone	3	
Upper Lias Clay	4		

Uppingham Rural District.

Captain J. E. O'CONNOR, M.O.H., says in his Annual Report for 1901, p. 4: "The water supply of the district is almost entirely from shallow wells. In a few instances . . . from springs. The shallow wells are often in such a situation as to be readily polluted by soakings from privies and drains."

Noted in other (earlier) notes:—

1883. Hallaton; well polluted by privy.
1885. Wing; some polluted wells.
1886. Gretton; a public well condemned, another well polluted.
1887. Uppingham; polluted well water.

ANALYSES OF SPRING WATERS.

CAMBRIDGESHIRE.

Cherry Hinton.

Northern side of high road at southern end of village.

See p. 40. Dr. J. C. THRESH, "Report on Fluorescein Experiments. . . . 1907."

Probable combination (in parts per 100,000):—

Ca	...	8·9	Calcium carbonate		20·35
Mg	...	·65	„ sulphate		2·55
Na	...	·26	Magnesium sulphate		·9
CO_3	...	12·2	„ chloride		1·75
SO_4	...	2·5	Sodium chloride		·55
Cl	...	1·7	„ nitrate		3·95
NO_3	...	2·85	Silica, etc.		2·45
			Total solid constituents dried at 180° C. ...		32·5

Hardness 24°.

Free ammonia	·006
Organic ammonia	·007
Nitrites	nil.

The following older analysis, from the Sixth Rep. Riv. Poll. Comm. 1874, pp. 123 and 327, is of interest for comparison:—

Chalk-springs. March 1873.
Temperature of the water 11·2° Centigrade. In parts per 100,000.

Total solid impurity	31·02
Organic carbon	·042
Organic nitrogen	·006
Ammonia	·001
Nitrogen as nitrates and nitrites...	·595
Total combined nitrogen...	·602
Chlorine	1·9

Hardness:—temporary, 17·6; permanent, 6·3; total, 23·9.

Fulbourn.

Butcher's Spring, northward of the Asylum.

Dr. J. C. THRESH, "Report on Fluorescein Experiments . . . . 1907."

Probable combination (in parts per 100,000):—

Ca	...	10·9	Calcium carbonate		21·25
Mg	...	·35	„ sulphate		4·65
Na	...	2·	„ chloride		2·75
CO_3	...	12·75	Magnesium chloride		1·35
SO_4	...	3·25	Sodium nitrate		7·1
Cl	...	2·7	Silica, &c.		1·9
NO_3	...	5·1	... ...		—
			Total solid constituents dried at 180° C. ...		39·

Hardness, 29°.

Free ammonia	·001
Organic ammonia	·003
Nitrites	nil.

Nine Springs.

Analyses by Prof. T. CLARK, in RANGER'S Report to the General Board of Health, 1849, p. 18 :—

	Hardness.	Alkalinity.
Nine Wells (Spring Head), Great Shelford	17·3°	15·25°
Hobson's Conduit	20°	15·90°
Trinity College Conduit (*see* pp. 57, 58.)	22°	—

RUTLAND.

Oakham.

Spring in Coldoverton Road, polluted.

Sixth Rep. Riv. Poll. Comm., 1874, p. 126.

In parts per 100,000.

Temperature of the water 7·3° Centigrade.

Total solid impurity	101·82
Organic carbon	·292
Organic nitrogen	·113
Ammonia	·001
Nitrogen as nitrates and nitrites	·322
Total combined nitrogen	·436
Chlorine	1·8

Hardness; temporary 43·6; permanent 45; total 88·6. Slightly turbid, palatable.

ANALYSES OF WATERS FROM WELLS.

CAMBRIDGESHIRE.

Barton.

Bore-hole at Oak Tree Coprolite Works, 1873.

Sixth Rep. Riv. Poll. Comm. 1874, pp. 97 and 327.

In parts per 100,000.

Temperature of the water 10·2° Centigrade.

Total solid impurity	72·04
Organic carbon	·104
Organic nitrogen	·017
Ammonia	·04
Nitrogen as nitrates and nitrites	·492
Total combined nitrogen	·542
Chlorine	7·6

Hardness; temporary 18·3; permanent 26·; total 44·3. Slightly turbid, palatable.

Bottisham.

Police Station, *see* p. 55. September 1895.

From E. De la Rue.

Appearance in two-foot tube, brownish, slightly turbid. Smell, when heated to 100° F. none.

In grains per gallon.

Total solid matter	27·
Chlorides [chlorine] (= chloride of sodium 13·01)	7·9
Nitrates (expressed as nitrogen)	None.
Ammonia, free	·0294
„ albuminoid	·0014
Oxygen absorbed by organic matter in 15 minutes at 140° F.	·0924

Metals.—A trace of iron.

Microscopic examination.—A slight deposit of oxide of iron.

Total solid matter, chlorides and nitrates fairly low and satisfactory. Free ammonia rather high, due to the presence of iron. Albuminoid ammonia and oxygen absorbed low, showing absence of organic matter.

The water is unpolluted and fit for drinking purposes. The slight deposit of iron is not injurious to health; but, if desired, can be removed by filtration, or by allowing it to subside.

Bourn.

East Hunts Water Co., *see* p. 56.

Two analyses by J. W. KNIGHTS, April, 1910, communicated by the Local Government Board.

A. Of the water as pumped out of the well, before being filtered.

B. Of the filtered water, from house-service tap, St. Ives.

In grains per gallon.

	A.	B.
Total solid matter	59·	59·
Chlorides	6·	5·6
Equal to chloride of sodium	9·88	9·22
Nitrates, expressed as nitrogen	none	none
Ammonia, free	·0413	·0028
Ammonia, albuminoid	·0014	·0021
Oxygen absorbed by organic matter in 15 minutes, at 140° F.	·0168	·0112
Metals	none	none
Appearance in two-foot tube	turbid	clear, pale blue.
Smell when heated to 100° F.	none	none

Microscopic examination.—A. Deposit of oxide of iron. B. No deposit.

Remarks.—A. Total solid matter and chlorides fairly low, and satisfactory. Albuminoid ammonia and oxygen absorbed low, showing absence of organic matter. Water unpolluted, and fit for drinking purposes. B. same as A., adding :—Free ammonia low. A very good and pure water, free from iron.

Two analyses by Messrs. VOELCKER, 27 July 1910.

A. Water taken from works, before filtration. B. From standpipe in Star Yard, St. Ives, direct from main (filtered water).

In grains per gallon.

	A.	B.
Total solid residue	68·6	68·32
Lime	17·64	17·08
Magnesia	4·74	4·74
Sulphuric acid, as sulphates	16·44	16·15
Nitrogen, as nitrates	none	·033
Equal to nitric acid	none	·126
Chlorine (equal to chloride of sodium 9·1)	5·53	5·53
Free ammonia	·036	none
Albuminoid ammonia	·001	·001

A. Contained some suspended matter. B. Bright and clear. Bacteriologic examination showed that the filtration was satisfactory.

The water is extremely hard, owing to the amount of salts of lime and of magnesia. Sulphate of lime is in considerable quantity, making the water permanently hard, and difficult to treat by any softening process. As a public supply its extreme hardness is a decided objection for ordinary domestic and washing purposes. As a drinking supply a water containing so much lime and magnesia-salts is not desirable.

Two analyses by the Clinical Research Assoc. 6th July, 1910.

1. From Stand-pipe in Star Yard, St. Ives, direct from main.
2. Unfiltered water, presumably.

In parts per 100,000 (in brackets, grains per gallon given for comparison with the other analyses).

Bourn, *cont.*

	1	2
Total solids dried at 120° C. ...	86·2(60·34)	91·5(64·05)
Combined chlorine	7·36(5·15)	7·5(5·25)
Expressed as NaCl.	12·14(8·5)	12·37(8·66)
Nitrogen as nitrates	0·04(·03)	·014(·01)
Nitrites	nil.	nil.
Saline ammonia	nil.	·059(·041)
Albuminoid ammonia	·0026(·0018)	·002(·0014)
Oxygen absorbed in 4 hours at 27° C.	·021(·015)	·019(·013)
Lead or copper	nil.	nil.

1. Hardness.—Temporary 21·7°; permanent 17·9°; total 39·6°
2. Hardness.—Temporary 22·7°; permanent 21·2°; total 43·9°.

1. Judged by chemical analysis it is of satisfactory organic purity after filtration, though the high figure for saline ammonia of an unfiltered sample suggests some degree of pollution, as it is not usual to find so much in water from a well only 80 feet deep.

Cambridge.

Sixth Rep. Riv. Poll. Comm., 1874, pp. 97 and 327.

Wells to Lower Greensand, March 1873. A. Running Pump in garden of St. John's College. B. Overflowing Well in Old Library Court, King's College.

In parts per 100,000.

	A.	B.
Total solid impurity	75·32	79·2
Organic carbon	·069	·073
Organic nitrogen	·021	·03
Ammonia	·074	·068
Nitrogen as nitrates and nitrites ...	0	0 8
Total combined nitrogen	•082	·0
Chlorine	7·6	7·6
Hardness, temporary	21·7	17·4
„ permanent	18·3	23·3
„ total	40·	50·7

Temperature of the water in A. 10·4° Centigrade, in B. 12°.

A. turbid, palatable. B. slightly turbid, slight odour of sulphuretted hydrogen.

Cambridge Waterworks, *see* pp. 45, 64, 65, 72, combined sources.

From Dr. COPEMAN'S Report to the Local Government Board, 1906.

Chemical analysis by E. F. SMITH, June 1905.

Sample from tap in the basement of the Pathological Laboratory, Cambridge:—

Clear, bright, of the highest organic purity. The water highly satisfactory for domestic use.

In grains per gallon; organic carbon and nitrogen in parts per 100,000.

Total solids	23·8
Ammonia	0
Nitrogen in nitrates and nitrites (= nitric acid 1·917)	·426
Oxygen required to oxidize organic matter	·003
Organic carbon	·041
Organic nitrogen	·009
Chlorine (= common salt 1·888)	1·152
Hardness, before boiling, 16·31°; after boiling, 3·29°	

Cambridge, *cont.*

Sir G. S. WOODHEAD said, July 5th 1905: "During the past half-year 131 bacteriological examinations of the Company's water have been made. I am glad to report as the result of these 131 examinations of water, drawn from a tap taken from the main before the water comes into the main buildings (of the Laboratory), that the average condition of the water is good, that the number of colonies growing on agar at the body temperature is low, and that . . . the average number of colonies was under 36 per c.c., or" deducting six occasions when the number was above the normal "under 15 per c.c. The number of liquefying organisms and organisms growing at the body temperature was not above the proportion that one would expect to find present in a good potable water."

He therefore reports the water as "of good bacteriological quality."

Castle Camps.

Made by J. W KNIGHTS, County Analyst for Cambridgeshire, 1896. Communicated by Mr. G. INGOLD.

Grains per gallon.

Total solid matter	176·
Chlorides as common salt	33·12
Ammonia, free	·062
„ albuminoid	·0014
Oxygen absorbed by organic matter in 15 minutes, at 140° F....	·0308

No nitrates. Slight trace of iron.

Microscopic examination.—Very small deposit of clay.

Temporary hardness 20°, permanent 79·5°.

"Total solid matter and chlorides are very high. The water contains much sulphates of lime and magnesia."

Cherry Hinton.

Cambridge Waterworks, *see* pp. 64, 65.

Lower Greensand source. A. From the bore-pipe, July 1883. By Dr. C. M. TIDY. B. From tank, December 1910. By E. F. SMITH.

In grains per gallon.

	A.	B.
Total solid matter	20·7	20·72
Ammonia	·001	·009
Nitrogen in nitrates and nitrites ...	None	·052
(= nitric acid)	—	·234
Oxygen required to oxidise the organic matter	None	None
Organic carbon } pts. per 100,000 ...	·021	·035
Organic nitrogen } pts. per 100,000 ...	·018	·008
Lime (CaO)	1·56	—
Magnesia (MgO)	·288	—
Sulphuric anhydride (SO_3)	1·87	—
Chlorine	1·368	1·44
(= common salt)	2·242	2·36
Hardness, before boiling	2°	2·82°
Hardness, after boiling	·4°	0
Silica	·78	—
Free oxygen, ...	1·96 cubic inches.	

Cherry Hinton, *cont.*

Chalk supply. C. From Spring Head, July 1883. By Dr. C. M. Tidy. D. From No. 3 Well, in Chalk, March 1909. By E. F. Smith.

In grains per gallon.

	C.	D.
Total solid matter	24·7	25·48
Ammonia	0	0
Nitrogen in nitrates and nitrites ...	·616	·458
(= nitric acid)	2·772	2·06
Oxygen required to oxidise the organic matter	·005	0
Organic carbon } parts per 100,000 ...	·030	·039
Organic nitrogen } parts per 100,000 ...	·021	·007
Lime (CaO)	10·46	—
Magnesia (MgO)	·324	—
Sulphuric anhydride (SO_3)	1·741	—
Chlorine	1·4	1·368
(= common salt)	2·35	2·242
Hardness, before boiling	18·8°	16·31°
Hardness, after boiling	3·2°	4·2°

The above, the general analysis of the Cambridge supply (p. 120) and the analysis of the Fulbourn water (below) are only examples of a long series. They have been communicated by the engineer, W. W. Gray, except the first, and in all cases the quality is noted as very good.

Fulbourn.

A. Asylum Well (*see* pp. 72, 73). B. Waterworks Well. Dr. J. C. Thresh, "Report on Fluorescein Experiments...1907."

In parts per 100,000.

—	A.	B.	Probable combinations.	A.	B.
Ca	8·7	8·4 (? ·35)	Calcium carbonate -	19·85	19·35
Mg	·55	·5	„ sulphate -	2·55	2·05
Na	1·4	1·6	Magnesium sulphate	·8	1
CO_3	11·9	11·6	„ chloride	1·6	1·2
SO_4	2·45 (? ·5)	2·25	Sodium chloride -	·8	1·15
Cl	1·7	1·6	„ nitrate -	3·95	4·05
NO_3	2·85	2·9	Silica, &c. - -	1·95	2·2
			Total solid constituents dried at 180° C. -	31·5	31

Hardness	A. 24°	B. 23°
Free ammonia	A. ·001	B. ·002
Organic ammonia	A. ·004	B. ·005
Nitrites	A. Nil.	B. Nil.

Cambridge Waterworks, *see* p. 72.
From Pilot-shaft, May 1903. By E. F. Smith.

In grains per gallon.

Total solid matter	23·2
Ammonia	0
Nitrogen in nitrates and nitrites (= nitric acid 1·917)	·426
Oxygen required to oxidise the organic matter ...	0
Organic carbon } parts per 100,000	·035
Organic nitrogen } parts per 100,000	0
Chlorine (= common salt 1·652)	1·008

Hardness.—Before boiling, 16·1°; after boiling, 3·7°.

Harston.

Sixth Rep. Riv. Poll. Comm., 1874, pp. 97 and 327.
Overflowing well, 200 feet deep, March 1873.
In parts per 100,000.

Total solid impurity	28·24
Organic carbon	·028
Organic nitrogen	·003
Ammonia	·05
Nitrogen as nitrates and nitrites	0
Total combined nitrogen...	·044
Chlorine	1·9

Hardness:—Temporary, 1·1; permanent, 2·5; total, 3·6.
Clear and palatable.

Dr. THRESH writes that this must be a carbonate of soda water, like that of Meldreth, *see* ADDENDA.

Heydon.

Heydon Grange, *see* p. 76.
Well, 80 feet deep, apparently all in chalk.
By Dr. J. C. THRESH. 8 February 1900.
In parts per 100,000.

		Probably combined as:—	
Ca	9·3	Calcium carbonate	19·4
Mg	·2	Calcium sulphate	1·85
Na	1·1	Calcium chloride	2·35
CO_3	11·5	Magnesium nitrate	1·2
SO_4	1·3	Sodium nitrate	4·1
Cl	1·5	Silica, &c.	1·1
NO_3	4·0		
Total solid constituents dried at 180° C.			30·

Hardness:—Temporary, 16·5°; permanent, 6·5°; total, 23°.

Free ammonia	0
Organic ammonia...	·004
Oxygen absorbed in three hours at 37° C.	·021
Nitrates	Nil

Clear and colourless.
The well is in or near a farm-yard.

Histon.

Fen Farm. Messrs. Chivers, *see* p. 76.
Made and communicated by Dr. J. C. THRESH. July 1912.
From Lower Greensand. Reaction neutral.
In parts per 100,000.

		Probable combinations.	
Ca	13·4	Calcium carbonate	13·3
Mg	4·8	Calcium sulphate	27·5
Na	35·7	Magnesium sulphate	23·7
CO_3	8·0	Sodium sulphate	87·3
SO_4	47·3	Sodium chloride	90·7
Cl	55·0	Etc.	1·5
NO_3	0·0	... ...	—
		Total solid constituents, dried at 180° C. ...	244·0

Hardness:—Temporary, 31°; permanent, 24°; total, 55°.

Free ammonia	·122
Organic ammonia...	·006
Oxygen absorbed in three hours at 37° C.	·0826
Nitrites	Nil

Isleham.

ELY WATER WORKS, *see* pp. 77, 78.

Made and communicated by Dr. J. C. THRESH. June 1898.

In parts per 100,000.

		Probable combinations.	
Ca ...	9·75	Calcium carbonate	18·7
Mg ...	·15	„ sulphate	2·1
CO_3 ...	11·2	„ nitrate	2·8
SO_4 ...	1·5	„ chloride	2·6
Cl ...	2·1	Magnesium chloride	·6
NO_3 ...	2·1	Aluminium oxide, silica, &c.	3·2
		Total solid constituents, dried at 180° C. ...	30·0

Hardness:—Temporary, 15°; permanent, 6°; total, 21°.

Free ammonia	Nil
Organic ammonia...	·005
Oxygen absorbed in three hours at 37° C.	·0321
Nitrites	Nil

Linton.

1. From E. DE LA RUE. March 1895.

Appearance in two-foot tube—clear, pale blue. Smell, none. Metals, none.

In grains per gallon.

Total solid mater	30·
Chlorides [? chlorine] (= Chloride of sodium 2·14)...	1·3
Nitrates	traces
Ammonia, free	·0014
Ammonia albumenoid	·0028
Oxygen absorbed	·0024
Microscopic examination. No deposit.	

Total solid matter, chlorides and nitrates are low and satisfactory. Free and albumenoid ammonia and oxygen absorbed are very low, and show absence of organic matter.

The water is unpolluted and fit for drinking purposes.

Presumably this is from the public supply, as is the following.

2. Public supply. Market Cross, *see* p. 78.

Made and communicated by Dr. J. C. THRESH. June 1898.

In parts per 100,000.

		Probable combinations.	
Ca ...	11·6	Calcium carbonate	27·7
Mg ...	·5	„ sulphate	1·8
Na ...	1·7	Magnesium sulphate	2·5
CO_3 ...	16·6	Water of hydration	·4
SO_4 ...	3·3	Sodium chloride	3·1
Cl ...	1·9	„ nitrate	2·
NO_3 ...	1·5	Silica, etc.	1·5
		Total solid constituents, dried at 180° C. ...	39·

Linton, *cont.*

Hardness, temporary 26°; permanent 4°; total 30°.

Free ammonia	0
Organic ammonia	0
Oxygen absorbed in 3 hours at 37° C.	·016
Nitrites	nil.

Melbourn.

From E. De la Rue. March 1895.

Appearance in two-foot tube, pale green, slightly turbid.
Smell, when heated to 100° F., none.

In grains per gallon.

Total solid matter	27·
Chlorides [? chlorine] (= Chloride of sodium 1·64)	1·
Nitrates	·1
Ammonia, free	·0035
„ albuminoid	·0014
Oxygen absorbed	·0025
Metals	none.

Microscopic examination, no deposit.

Total solid matter, chlorides and nitrates low and satisfactory. Free and albuminoid ammonia and oxygen absorbed are low, and show absence of organic matter.

The water is unpolluted and fit for drinking purposes.

Newmarket.

Waterworks, *see* p. 84.

1. *Water Works Directory*, 1911. Feb. 1911.

2. By J. W. Knights. From the Local Government Board. Feb. 1913.

In grains per gallon.

	1.	2.
Total solid matter	20·	18·
Chlorine	1·5	1·7
= Sodium chloride	2·47	2·8
Nitrates expressed as nitrogen	·33	·25
Ammonia, free	·0007	trace
„ albuminoid	·0007	·001
Oxygen absorbed by organic matter in 15 minutes, at 140° F.	·014	·014

Appearance in 2-foot tube—clear, pale blue, in both. Smell, when heated to 100° F.—none, in both.

Metals—none, in both.

Microscopic examination:—1, no deposit; 2, satisfactory.

1. Total solid matter, chlorides, and nitrates low. Free and albuminoid ammonia and oxygen absorbed low, showing the absence of organic matter. Water unpolluted and fit for drinking purposes.

Pampisford.

The Spike. *See* p. 86.

Made and communicated by Dr. J. C. Thresh. June 1898.

In parts per 100,000.
Probable combinations:—

Ca	...	11·05	Calcium carbonate...	...	25·8
Mg	...	·5	„ sulphate ...	...	2·55
Na	...	1·9	Magnesium sulphate	...	2·5
CO^3	...	15·5	Water of hydration	...	·4
SO	...	3·8	Sodium chloride ...	...	3·1
Cl	...	1·9	„ nitrate ...	...	2·6
NO_3	...	1·9	Aluminium oxide, silica, &c.	...	2·05
			Total solid constituents dried at 180° C.	...	39·

Hardness, temporary 26°, permanent 4°, total 30°.

Free ammonia	0
Organic ammonia	0
Oxygen absorbed in 3 hours at 37° C.	·015
Nitrites	Nil.

Royston.

Waterworks.

Entered here by mistake. The town is now wholly in Hertfordshire.

By J. W. Knights. September 1909.

Communicated by the Local Government Board.

In grains per gallon.

Total solid matter	21·
Chlorides (= sodium-chloride 1·97)	1·2
Nitrates, expressed as nitrogen	·3
Ammonia, free	·0007
„ albuminoid	·0007
Oxygen absorbed by organic matter in 15 minutes at 140° F....	·014
Metals	None

Appearance in 2-foot tube, clear, pale blue.

Smell when heated to 100° F, none.

Microscopic examination. No deposit.

Remarks.—Total solid matter, chlorides and nitrates are low and satisfactory. Free and albuminoid ammonia and oxygen absorbed are very low, showing absence of organic matter. The water is unpolluted and fit for drinking purposes: it is very pure.

Sawston.

Cottages, a mile N.W. of Church, *see* p. 88.

Made and communicated by Dr. J. C. Thresh. 10th January 1920.

Trace of suspended chalk. Colour, yellow-green. Odour, none. Reaction neutral.

In parts per 100,000.
Probable combinations:—

Ca	...	12·	Calcium carbonate	...	28·3
Mg	...	·55	„ sulphate	...	2·4
Na	...	3·4	Magnesium sulphate	...	2·65
CO_3	...	17·	Sodium sulphate	...	3·7
SO_4	...	6·34	„ chloride	...	3·95
Cl	...	2·	„ nitrate	...	2·35
NO_3	...	1·75	Silica, &c.	...	1·65
			Total solid constituents dried at 180° C.	...	45·

Hardness, temporary 23°, permanent 7°, total 30°.

Free ammonia	·003
Organic ammonia	·003
Oxygen absorbed in 3 hours at 37° C.	·002
Nitrites	Nil.

Shepreth.

Rectory Farm.

Made and communicated by Dr. J. C. Thresh. January 10th, 1920.

Trace of ferruginous chalk deposited. Yellow tint. Odour none. Reaction neutral.

In parts per 100,000.
Probable combinations :—

Ca	...	11·7	Calcium carbonate	...	29·2
Mg	...	5·5	Magnesium carbonate	...	1·25
Na	...	2·3	„ sulphate	...	1·0
CO_3	...	18·4	Sodium sulphate	...	1·2
SO_4	...	1·6	„ chloride	...	3·95
Cl	...	2·4	„ nitrate	...	1·35
NO_3	...	1·	Silica, &c.	...	1·05
			Total solid constituents dried at 180° C.	...	39·

Hardness, temporary 24°, permanent 4°, total 28°.

Free ammonia	·009
Organic ammonia	·0034
Oxygen absorbed in 3 hours at 37° C.	·0280
Nitrites	Nil.

Soham. In grains per gallon.

——	A.	B.	C.	D.	E.	F.	G.
Total solid matter ...	194·	135·	133·	143·	95·	102·	103·
Chlorides	40·9	42·	42·35	42·	37·1	38·15	36·5
Equal to sodium-chloride.	67·4	69·54	69·79	69·21	61·14	62·87	63·44
Nitrates, expressed as nitrogen.	trace	trace	trace	trace	none	none	none
Ammonia, free ...	·0763	·0413	·0007	·0021	·0903	·0854	·0959
„ albuminoid	·0042	·0021	·002	0035	·0021	·0049	·0021
Oxygen absorbed in 15 mins. at 140° F.	·0476	·0368	·028	·0448	·0252	·0756	·182
Metals	none	none	none	none	deposit of iron-oxide.	none	none
Appearance in 2-foot tube.	yellow, turbid	pale blue, very slightly turbid.	pale blue, very slightly turbid.	turbid	turbid	deep yellow, very turbid.	very turbid
Smell when heated to 100° F.	objectionable	none	none	none	none	slightly objectionable.	slight

Soham.

Various Well-waters. By J. W. KNIGHTS. Information from the Local Government Board. *See* p. 91.

A. Public Pump near King's Head, 23rd July 1913. B. King's Head, 21st August 1913. C. King's Head (33 feet of water in well) 29th August 1913. D. Ditto (? date). E. Fordham Road, 29th August 1913. F. Public Well, Brook Dam Lane, near Red Lion Square, 30th July 1913. G. Brook Dam Lane, 10th September 1913 (same place as F.).

Microscopic Examination.—A. Deposit of organic matter. B. Slight deposit of earthy matter. C. Slight deposit of earthy matter and a few vegetable fibres. D. Much deposit of earthy matter. F. Much deposit of earthy and organic matter. G. Much deposit of earthy matter.

Hardness, in A. Temporary 7·2°, permanent 16·6°.

Remarks. A. Total solid matter and chlorides excessively high and unsatisfactory. Free and albuminoid ammonia and oxygen absorbed high, showing the presence of organic matter.

Appearance, smell and microscopic examination bad. Water polluted with sewage and unfit for drinking purposes.

B. Total solid matter and chlorides very high. Nitrates low. Albuminoid ammonia and oxygen absorbed low, showing absence of organic matter. Water unpolluted and fit for drinking purposes.

C. Total solid matter and chlorides very high. Free and albuminoid ammonia and oxygen absorbed low, showing absence of organic matter. Water unpolluted and fit for drinking purposes.

D. Total solid matter and chlorides very high. Free and albuminoid ammonia and oxygen absorbed fairly low, showing absence of any considerable quantity of organic matter. Water very turbid, and for that reason not satisfactory. If got clear it would be fit for drinking purposes.

E. Total solid matter and chlorides high. Albuminoid ammonia and oxygen absorbed low, showing absence of organic matter. Turbidity due to iron-oxide, which should be removed. Water unpolluted and fit for drinking purposes.

F. Total solid matter and chlorides very high and most unsatisfactory. Free and albuminoid ammonia and oxygen absorbed high, showing presence of organic matter. Microscopic examination bad. Water polluted with sewage, and unfit for drinking purposes.

G. Total solid matter and chlorides very high and unsatisfactory. Free ammonia and oxygen absorbed very high, showing presence of much organic matter. Water polluted with organic matter and unfit for drinking purposes.

Of the four samples from the King's Head Public Well (A. to D.) the first was taken before the alterations (*see* p. 91) from the bore, the last when there was only 9 inches of water in the well.

The following are added from a communication in the *Cambridgeshire Times* of 4th April 1913. Also apparently by J. W. KNIGHTS:—

1. Moat Terrace, January 1901. 2. Pettitt's Hall Street. 3. Mr. Leonard's.

In grains per gallon?

	1.	2.	3
Total solid matter	300·	135·	106·
Chlorides	26·	18·9	37·9
Equal to sodium-chloride	43·34	31·14	62·45
Nitrates, expressed as nitrogen	2·5	4·	·4

Soham, *cont.*

Remarks.—1. Total solid matter, chlorides and nitrates very excessive. Free and albuminoid ammonia and oxygen absorbed very high, showing presence of much organic matter. Water highly polluted with sewage, and unfit for drinking purposes. 2. Total solid matter, chlorides and nitrates very high, indicating presence of sewage. Free and albuminoid ammonia and oxygen absorbed very excessive, showing presence of much organic matter. Water highly polluted with sewage and unfit for drinking purposes. 3. Total solid matter and chlorides very high, nitrates fairly low. Free and albuminoid ammonia and oxygen absorbed rather high, showing presence of organic matter. Water not of satisfactory purity, and ought not to be used for drinking purposes.

Stetchworth.

Public Supply (Boring). *See* p. 92.

By J. W. KNIGHTS, February 1901. From the Local Government Board.

In grains per gallon.

Total solid matter	37·
Chlorides (equal to chloride of sodium 4·12)	2·5
Nitrates, expressed as nitrogen	None.
Ammonia, free	·0021
„ albuminoid	·0007
Oxygen absorbed by organic matter in 15 mins. at 140° F.	·0112
Metals	None.

Appearance in 2-foot tube, clear, pale blue.

Smell, when heated to 100° F., none.

Microscopic examination.—No deposit.

Total solid matter, chlorides and nitrates all low.

Free and albuminoid ammonia and oxygen absorbed all very low showing absence of organic matter.

The water is unpolluted and fit for drinking purposes.

Swaffham Prior.

Mr. T. Allen's, 1898.

From E. DE LA RUE.

In grains per gallon.

Appearance in 2-foot tube, clear, pale blue.

Smell, when heated to 100° F., none.

Total solid matter	23·
Chlorides [? Chlorine] (= common salt, 2·14) ...	1·3
Nitrates	·6
Ammonia, free	·0021
„ Albuminoid	·0077
Oxygen absorbed by organic matter in 15 mins. at 140° F.	·0252
Metals	None.

Microscopic examination.—No deposit.

The water is unpolluted and fit for drinking purposes.

Thorney.

Bukehorn Toll Farm. *See* pp. 94, 95.

Boring. Yield, 4,000 gallons a day.

Communicated by the Bedford Office, Thorney.

Made by J. West Knights, April 1908.

In grains per gallon.

Total solid matter	245·
Chlorides	87·5
Equal to chloride of sodium (common salt) ...	144·2
Nitrates	None.
Ammonia, free	·1253
„ albuminoid	·0021
Oxygen absorbed by organic matter in 15 mins. at 114° F.	·0504

Metals—none.
Appearance in 2-foot tube—turbid.
Smell when heated to 100° F.—none.

Microscopic examination.—A deposit of earthy matter.

Remarks.—The total solid matter and chlorides are very high, showing the presence of much saline matter. The albuminoid ammonia and the oxygen absorbed are low, showing the absence of organic pollution.

Fit for drinking, the saline matter being in no way injurious.

Whittlesey.

Sixth Rep. Riv. Poll. Comm., 1874, p. 88.

Two wells in the town, both 15 feet deep. (In gravel?).

In parts per 100,000.

Total solid impurity	250·2	286·1
Organic carbon	·931	·922
Organic nitrogen	·94	·201
Ammonia	3·05	·74
Nitrogen as nitrates and nitrites	10·848	11·265
Total combined nitrogen	14·3	12·075
Chlorine	28·2	26·4
Hardness { temporary	35·7	13·5
Hardness { permanent	54·4	89·3
Hardness { total	90·1	102·8

The first clear and palatable. The second slightly turbid, palatable.

Wisbech.

By L. Playfair (Lord Playfair) in W. Lee's Report to the General Board of Health, 1850, pp. 70, 71.

1. Deadman's Pond Pump.

Sample "exceedingly turbid, owing to a large amount of oxide of iron mixed with vegetable matter. Hardness 48·2°."

Wisbech, *cont.*

2. Union Workhouse pump well.

Sample "contained a large deposit of oxide of iron. Hardness 56·7°."

In grains per gallon.

	1.	2.
Silica	1·44	2·44
Phosphate of lime	1·38	·9
Sulphate of lime	16·18	26·44
Carbonate of lime	20·86	8·06
Carbonate of magnesia	13·54	19·87
Chloride of potassium	11·87	6·47
Chloride of sodium	6·06	5·3
Sulphate of soda	6·37	3·75
Organic matter	3·15	7·35
Total	80·85	80·58

HUNTINGDONSHIRE.

Huntingdon.

Waterworks, *see* p. 104.

By the Clinical Research Association.

1. From First Sump Hole 1903.
2. From Reservoir.

In grains per gallon.

	1.	2.
Total solids, dried at 120° C	37·24	37·94
Combined chlorine	2·45	2·45
Expressed as Sodium-Chloride	4·04	4·04
Nitrogen as nitrates	·15	·18
Nitrites	nil.	nil.
Saline ammonia	·0011	·0007
Albuminoid ammonia	·0045	·00073
Oxygen absorbed in 4 hours at 27° C.	·026	·026
Lead or copper	nil.	nil.
Total hardness	26·4	26·4

1. A water of moderate organic purity, but rather hard. Judged by chemical analysis alone it should be a fairly safe drinking water.

Bacteriologic examination.—The number of organisms which grew on gelatine incubated at 22° C. for 5 days was 21 per. c.c. of the water, a number much below the average, and as *Bacillus coli communis, B enteritidis sporogenes* and *Streptococci* were not found, the water is suitable for drinking purposes from a bacteriologic standpoint.

2. The albuminoid ammonia is a little high, but the oxygen absorbed and nitrates are low.

It is not quite so good as No. 1, but may be considered a fairly safe water for drinking in view of the satisfactory bacteriologic examination. The number of organisms which grew on gelatine incubated at 22° C. for 5 days was 33 per c.c. of the water, which is much below the average. *Bacillus coli communis, B. enteritidis sporogenes* and *Streptococci* could not be found.

Clinical Research Soc. 1901.

Sample from Sumps :—

"The number of organisms which produced colonies upon gelatine from 1 c.c. of the water was 24. A qualitative Bacteriological Examination did not reveal the presence of *Bacillus Coli Communis*, or of any other suspicious organism. Bacteriologically this is an exceptionally pure water."

Sample from Tank :—

"The number of organisms which produced colonies upon gelatine from 1 c.c. of the water was 105. Neither the *Bacillus Coli Communis* or any other suspicious organism was found."

"The number of organisms although fairly high is not excessive for water stored in a tank."

"The qualitative examination gives no indication of sewage contamination."

"Bacteriologically this may be regarded as a good water."

Orton Waterville.

Analyses by Dr. C. B. M. Blundell, January 1917.

1. Frisby's Well. 2. Village Well. 3. Beeby's Well. 4. School Well.

In parts per 100,000.

	1.	2.	3.	4.
Total solid matter	190·	100·	95·71	107·1
Chlorides	13·43	7·71	4·56	8·85
Equal to choride of sodium	22·13	12·7	8·	14·6
Nitrates, expressed as nitrogen	5·71	·78	4·43	3·71
Ammonia, free	Trace	·001	Trace	None
Ammonia albuminoid ...	·536	·019	·017	·019
Oxygen absorbed by organic matter in 15 mins. at 140° F.	·3	·452	·104	·148
Metals...	None	None	None	None

Appearance in 2-foot tube :—1. Deep yellow, turbid. 2. Very deep yellow, turbid. 3. Pale yellow, turbid. 4. Deep yellow, slightly turbid.

Smell when heated to 100° F. None in any.

Microscopic examination. 1. 2. 3. Deposit of organic matter.

1. Total solid matter, chorides and nitrates very high and most unsatisfactory, especially nitrates. Albuminoid ammonia and oxygen absorbed very high, showing presence of much organic matter. Appearance and microscopic examination bad. The water seems to be highly polluted with sewage.

2. Total solid matter and chlorides rather high. Nitrates moderate.

Albuminoid ammonia and oxygen absorbed very high, showing presence of much organic matter. Appearance and microscopic examination very bad. The water seems to be polluted with sewage.

3. Total solid matter and nitrates very high, especially the latter, which indicates infiltration of sewage. Albuminoid ammonia and oxygen absorbed high, showing presence of organic matter. Microscopic examination bad. The water seems to be polluted with sewage.

4. Total solid matter, chlorides and nitrates high, especially nitrates, Albuminoid ammonia and oxygen absorbed are high, showing presence of much organic matter. Appearance and microscopic examination bad. The water seems to be polluted with sewage.

Later analyses (? by same) 31 March 1914, of all but 4.

	1.	2.	3.
Total solid matter	184·28	78·57	95·71
Chlorides	17·42	5·71	5·
Equal to chloride of sodium ...	22·12	9·41	8·21
Nitrates, expressed as nitrogen ...	6·42	·57	4·28
Ammonia, free	Trace	Trace	·005
Ammonia albuminoid	·032	·013	·014
Oxygen absorbed by organic matter in 15 mins. at 140° F.... ...	·2914	·124	·124

The other remarks are much as before, and there seems no reason to give them. In 2. Total solid matter, chlorides and nitrates, are fairly low.

St. Neots.

Waterworks. *See* p. 107.

Communicated by G. Deacon.

Analyses of two samples by Dr. (Sir T.) Stevenson.

In grains per gallon.

	A.	B.
Date of collection:—	February 1899.	January 1899.
Colour	Almost nil.	Pale yellow.
Odour	None.	None.
Turbidity	Very slight.	Slight.
Total solid matter... ...	19·6	19·32
Loss on ignition	1·12	·28
Chlorine in combination ...	·7	·84
Equal to common salt ...	1·15	1·38
Nitrogen as nitrates ...	·01	·01
„ „ nitrites ...	None.	None.
Sulphuric Acid (SO_3) ...	·73	·97
Lime (CaO)	6·6	5·58
Magnesia (MgO)	·67	1·15
Oxide of Iron	Traces.	·1
Silica (SiO_2)	·45	·64
Ammonia	·015	·016
„ albuminoid or organic	·0015	·0005
Oxygen required to oxidise the organic matter ...	·011	·005
Hardness, temporary ...	13·8	13·7
„ permanent ...	None.	None.
„ total	13·8	13·7

Practically identical waters. Their saline constituents are low and none of them are objectionable either in quality or amount. Their hardness is moderate and all the hardening salts are removable by boiling.

They are non-ferruginous and the amount of magnesia salts is inconsiderable.

They are of the highest degree of organic purity and admirably fitted for a public supply for drinking, domestic and all ordinary purposes.

Two later analyses, by T. P. Wright, Medical Officer of Health. A. March 1911. B. December 1913.

In grains per gallon.

	A.	B.
Total solid matter	32·5	33·8
Chlorides	2·8	2·3
Equal to chloride of sodium	4·62	3·79
Nitrites	Absent.	Absent.
Nitrates, expressed as nitrogen ...	·2	Faint trace.
Ammonia, free	·0035	·0048
„ albuminoid...	·0021	·00266
Oxygen absorbed by organic matter in 15 mins. at 140° F.	·32	·32

In parts per million.

Metals	Nil.	Nil.
Appearance in 2-ft. tube	Bright and clear.	White and clear.
Smell, when heated to 100° F. ...	Nil.	Nil.
Hardness	About 22°	About 18°

This water maintains its original purity. The difference in each quarterly analysis is very small.

Stibbington.

Water Supply. Boring in Northamptonshire.

By L. Pugh (Messrs. Richardson & Co., Leicester), May 1913.

	In grains per gallon.
Total solid matter	35·
Nitrogen in nitrites and nitrates	Trace
Chlorine	1·3
Metals. Lead or copper	None.
	In parts per million.
Ammonia, free and albuminoid	None.
Hardness, 27·5°	

RUTLAND.

Braunston.

Oakham Waterworks.

Analysis by Dr. Bernard Dyer, May 1906.

In grains per gallon.

Total dissolved matter	24·92
Loss on incineration of residue	·84
Chlorine in chlorides (= Chloride of sodium 2·47)	1·5
Nitrogen in nitrates	Inappreciable.
Free (actual or saline) ammonia	·003
Albuminoid (organic) „	·001
Oxygen absorbed by oxidisable organic matter, from a solution of permanganate of potash, at 80° F. in 15 mins.	·005
Ditto in four hours	·011
Phosphoric acid	Traces.

Water softened, and then from 7 to 9 degrees of hardness.
A pure water, of good quality for drinking and domestic purposes.

Oakham.

From a well supplying four cottages opposite the Gasworks, Braunston Road.

By L. C. Wilson, of Newark, March 1912.

Suspended matter, none. Appearance, clear.

Grains per gallon.

Total solids at dull red heat	99·41
Total chlorine	6·6
Nitrogen in oxidised forms	Traces.

Parts per 100,000.

Free ammonia	None.
Albuminoid ammonia	·018
Oxygen in one hour	·067
Oxygen in three hours	·067

Sewage-organisms, none. Sediment, none.
"A good water, and suitable for domestic purposes."

Another analysis, by Dr. Christopher Lolleston, County Medical Officer of Health, March 1912.

In grains per gallon.

Free ammonia	Faint trace.
Chlorides	7·
Nitrites	2·
Nitrates	Nil.
Oxygen absorbed in four hours at room-temperature	·10

"The water is quite unfit for drinking." This condemnation (contradictory to the above) is "on account of the high chloride and high nitrate figure."

J. E. O'Connor, the District Medical Officer of Health, says of this water, and of two other waters (from a house in Park Lane and from houses in West Road) all analysed in January 1912, that "all three samples furnish evidence of animal organic contamination, and are unsuitable for drinking."

Oakham, *cont.*

Sixth Rep. Riv. Poll. Comm., 1874, p. 79.

1. Well under a house. 2. Well in St. John's Court, John Street. 3. Well in Cook's Yard, Northgate Street.

In parts per 100,000.

	1.	2.	3.
Total solid impurity	97·8	204·1	142·8
Organic carbon	·129	·227	·133
Organic nitrogen	·06	·103	·051
Ammonia	·001	·152	·001
Nitrogen as nitrates and nitrites ...	3·697	8·136	6·795
Total combined nitrogen	3·758	8·364	6·847
Chlorine	10·6	23·6	13·4
Hardness { temporary	24·7	34·4	35·2
Hardness { permanent	16·	61·3	29·1
Hardness { total	40·7	95·7	64·3

All clear and palatable.

Uppingham.

Waterworks.

Surface-supply, well, 20 feet deep (taken from consumer's tap),

By the Clinical Research Association. August 1910.

In parts per 100,000.

Chemical.

Total solids, dried at 120° C.	25·3
Combined chloride (expressed as NaCl, 2·59) ...	1·56
Nitrogen as nitrates	·03
Nitrites	nil.
Saline ammonia	nil.
Albuminoid ammonia	·0077
Oxygen absorbed in 4 hours at 27° C.	·031
Lead or copper	nil.

*Total hardness (after softening) 10·2°.

Bacteriological.

Average number of organisms producing visible colonies on gelatine-plates, incubated at 20–22° C. for 3 days, 18 per c.c.

Ditto on agar-plates, incubated at 37·5° C. for 2 days, 3 per c.c.

B. coli and *B. enteritidis sporogenes* not found in 100 c.c. *Streptococci*, not found in 30 c.c.

By the Clinical Research Association. October 1913.

In parts per 100,000.

Chemical.

Total solids dried at 120° C.	34·8
Combined chlorine (equivalent to NaCl, 3·88) ...	2·35
Nitric nitrogen	·01
Nitrous nitrogen...	nil
Ammoniacal nitrogen	·008
Albuminoid nitrogen	·0094
Oxygen absorbed in 4 hours at 27° C.	·071
Lead or copper	nil

Hardness (equivalent to $CaCO_3$), temporary 10, permanent 13, total 23.

* Another note says before softening 23·5°, after 7·5°.

Uppingham, *cont.*

Bacteriological.

Average number of organisms producing visible colonies on gelatine-plates, incubated at 20–22° C. for 3 days, 100 per c.c. Ditto on agar-plates, incubated at 37·5° C. for 2 days, 2 per c.c.

B. coli and *B. enteritidis sporogenes*, not found in 100 c.c.

Streptococci not found in 30 c.c.

"These results afford no evidence of recent pollution with sewage or animal excreta, and the sample is . . . . of satisfactory organic and bacterial purity for a water of this class and of moderate hardness."

Clinical Research Association. March 1919.

Chemical.

In parts per 100,000.

Total solids, dried at 120° C.	30·
Combined chlorine (equivalent to NaCl, 2·97) ...	1·8
Nitric nitrogen	·14
Nitrous „	nil
Ammoniacal nitrogen	·005
Albuminoid „	·0102
Oxygen absorbed in 4 hours, at 27° C.	·062
Lead or copper	nil

Hardness, temporary (equivalent to $CaCO_3$), 10·3, permanent 10·5, total 20·8.

Bacteriological.

Average number of organisms producing visible colonies on gelatine-plates incubated at 20–22° C. for 3 days, 8,490 per c.c. Ditto on agar-plates, incubated at 37·5° C. for 2 days, 10 per c.c.

B. coli and *B. enteritidis sporogenes*, not found in 100 c.c.

Streptococci not found in 30 c.c.

Chemical analysis shows the water to be fairly satisfactory; the albuminoid nitrogen is however somewhat high.

Bacteriologically there is no evidence of sewage-pollution, the high figure for the gelatine-count being probably due to multiplication of the organisms during transit, owing to the absence of ice.

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All accounts of wells in the Geological Survey Memoirs, and in the various papers, &c., have been included in this volume, sometimes with additions or corrections and all such matter as seemed fitting for the present purpose has been extracted. But it is well to have a systematic list, to enable readers to see things for themselves.

The letters C.H.R. at the head of titles show the counties to which they refer.

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Sheets of the Index Map. Scale, four miles to an inch.

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List repeated (with corrections to date) in Report for 1913, p. 5, and again in Report for 1914, pp. 9, 10.

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Partly supplements, and is partly supplemented by his map in *Rep. R. Comm. Water Supply Metrop.*, 1893.

ADDENDA.

The following notes have come to hand since this Memoir was set up in pages.

Sawtry.

Ordnance Map 172, new series. (Huntingdonshire 9, S., 13, N.)
Geologic Map 64.

In his Report to the General Board of Health on a Preliminary Inquiry into the Supply of Water of Sawtry All Saints and Sawtry St. Andrew in 1850, G. T. Clark said: "The whole of this district is very ill supplied with water. There are not above five springs in the two parishes, and several of them are at times brackish." Pond-water is the usual supply.

Sawston. (*See* page 87.)

Messrs. Spicer's Paper Mills, 70 feet above Ordnance Datum. Bored and communicated by Messrs. Le Grand and Sutcliff.

Rest-level of water 7½ feet down. A long test gave a yield of 124,300 to 142,800 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil (9 inches) ...	Chalk and mould	3	3
[Lower Chalk] ...	Rubbly chalk	5	8
	Chalk...	60	68
	Hard chalk	25	93
	Sandy or granulated chalk	7	100
	Chalk and loamy sand ...	11	111
	Sticky chalk	6	117
	Hard chalk	12	129
	Chalk and sandstone ...	8	137
Gault and septaria	... ...	169	306
[Lower Greensand] ...	Ironstone	1	307
	Sand and clay	10	317
	Sandstone	3	320
	Sand and clay	16	336
	Green sand	10	346
	Dark sand and clay ...	20	366
	Dark sand	7	373
	Stone	½	373½
Kimeridge Clay	... ...	1½	375

The top 11 feet classed as Lower Greensand may be Gault.

Upton.

Ordnance Map 172, new series. (Huntingdonshire 13, S.E.)
Geologic Map 52, N.E.

Rectory, 1897.

Communicated by W. C. Easdale, from local information.

About 150 feet above Ordnance Datum.

Sunk about 70 feet and lined with dry brick steining; then bored another 70 feet. Very little water was found, and that not good.

Blue clay, with some chalk mixed with it [Boulder Clay] for a certain depth.

Very dark clay, almost black [Oxford Clay]. Very treacherous to dig.

On July 11th, 1921, in spite of the prolonged drought, water stood at about 20 feet down. A sample was analysed by Dr. S. Rideal, who reported as follows, 22nd July 1921:—

This water is unsuitable for drinking purposes owing to the large amounts of chloride and sulphate present. I do not consider it amenable to treatment. The organic matter present is probably of vegetable origin.

Physical examination :

The sample was slightly opalescent, had a very faint yellow tint, and was odourless. A minute trace of sediment was present.

Chemical analysis, in parts per 100,000.

Total solids	534·5
Chlorine (= 165· NaCl, common salt)	100·
Free ammonia	·0004
Albuminoid ammonia	·0205
Nitrates (as nitrogen)	Nil
Nitrites	Nil
Oxygen consumed	·365

Alkalinity per 500 cc. 10·4 cc. (= carbonate of lime).

Sulphuric anhydride 161·7 (= 286·7 sulphate of soda).

Test for sulphuretted hydrogen negative.

Meldreth. (*See* page 82.)

Sample of water from an artesian well near Meldreth. Made June 1921, and communicated, by Dr. J. C. Thresh.

A fairly alkaline water, normal in appearance.

In parts per 100,000.

Chlorine in chlorides (= chlorides 3·7)	2·2
Nitric nitrogen (= nitrates ·21)	·04
Free ammonia	·040
Albuminoid ammonia	·003
Oxygen absorbed	·038

Hardness 5°.

Contained approximately 5 parts of calcium-carbonate and 16·6 parts of sodium-carbonate per 100,000.

Resembles the alkaline waters from the London Basin.

The "Preliminary Report" of the Census of 1921 was issued after this Memoir was set up in pages, too late for alteration of the tables on pp. 1, 2. The following figures are taken from this Report :—

	1921.	Increase.	Decrease.
Cambridgeshire	129,594	1,272	—
Isle of Ely	73,778	4,026	—
Cambridge	59,262	3,450	—
Wisbech	11,316	494	—
March	8,939	536	—
Ely, City	7,690	—	227
Chatteris	5,086	—	173
Huntingdonshire	54,748	—	829
Old Fletton*	5,636	631	—
Ramsey	5,136	—	192
Rutland	18,368	—	1,978

It is of interest to note, of towns under 5,000, that Whittlesey has an increase of 1 (from 4,207 to 4,208), and Huntingdon one of 191 (from 4,003 to 4,194,) placing it ahead of St. Neots, which has decreased 62 (from 4,171 to 4,109). Were Godmanchester joined with Huntingdon, the population of the county-town would be increased by 2,034, bringing it to a total of well over 6,000.

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*This place gets its water-supply from Peterborough, in another county.

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Names of Persons, etc., are in small capitals.
Names of Places are in italics.
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